Proceedings of the 38th Annual National Conference of Technology Education Practitioners Association of Nigeria

(Formerly Nigerian Association of Teachers of Technology, NATT)

Theme:
Utilization of Digital Skills and AI on TVET for Economic Diversification in the 21st Century Educational Landscape

ISBN: 978-978-967-443-5

ABUJA
2025

Proceedings of the 38th Annual National Conference of Technology Education Practitioners Association of Nigeria

(Formerly Nigerian Association of Teachers of Technology, NATT)

Theme:
Utilization of Digital Skills and AI on TVET for Economic Diversification in the 21st Century Educational Landscape

Event at:
Dr. Gambo Hamza Hall, Permanent Site, FCT COE, Zuba, Abuja
July, 7th – 11th 2025

Published by:
Technology Education Practitioners Association of Nigeria
c/o School of Technical Education, FCE (T) Akoka. Lagos State
www.natt.org editoratepan@gmail.com editornatt@gmail.com

© 2025 TEPAN
ISBN: 978-978-967-443-5 (Print)
eISBN: 978-978-967-444-3 (Online)

All rights reserved. Apart from any fair dealing for the purpose of private study, research, criticism or review as permitted under the Creative Commons Attribution-Non-Commercial No-Derivative License 4.0, no part of this publication may be reproduced in any form or any means without prior written permission of the publisher.

Articles published in this Book of Proceedings have undergone a formal process of peer review by accredited referees. Responsibility for the contents of these articles rests upon the authors and not the publisher.

Data presented and conclusions developed by the authors are for information only and are not intended for use without independent substantiating investigations on the part of the potential user.

Citation:
In: A. M. Hassan, H. R. Sa'i, A. S. Bappah, N. N. Afaor, & B. A. Wakili (Eds) *Proceedings of the 38th Annual National Conference and Annual General Meeting of Technology Education Practitioners Association of Nigeria* (pp.) Lagos: Technology Education Practitioners Association of Nigeria (TEPAN)

Proceedings of the 38th Annual National Conference of Technology Education Practitioners Association of Nigeria

(Formerly Nigerian Association of Teachers of Technology, NATT)

ATEPAN Editorial Board

Editor – in – Chief: Prof. A. M. Hassan
Federal University of Technology, Minna, Niger State

Deputy Editor – in – Chief: H. R. Sai
Kaduna Polytechnic, Kaduna, Kaduna State

Associate Editors: Prof. A. S. Bappah
Abubakar Tafawa Balewa University, Bauchi, Bauchi State
Prof. P. S. Williams
University of Uyo, Uyo, Akwa-Ibom State

Editorial Secretary: Dr. B. A. Wakili
Federal College of Education (Technical), Potioskum, Yobe State.

Editorial Advisory: Prof. K. A. Salami
Federal University of Technology, Minna, Niger State
Prof. K. R. E. Okoye
Nmamdi Azikwe University Awka, Anambra State
Prof. O. T. Ibeneme
Nmamdi Azikwe University, Awka, Anambra State
Dr. N. G. Nneji
Federal College of Education (Tech), Akoka, Lagos State
Prof. J. D. Enemali
Abubakar Tafawa Balewa University, Bauchi, Bauchi State
Prof. V. V. Apagu
Modibbo Adama University of Technology, Yola, Adamawa State

Proceedings of the 38th Annual National Conference of Technology Education Practitioners Association of Nigeria

(Formerly Nigerian Association of Teachers of Technology, NATT)

TEPAN Executive Council

National President:	Prof. A. S. Bappah Abubakar Tafawa Balewa University, Bauchi, Bauchi State
Deputy National President:	Dr. Natheniel Nguuma Afaor Benue State University, Markudi, Benue State
Vice President (North-East):	Dr. A. S. Yaro Abubakar Tatari Polytechnic, Bauchi, Bauchi State
Vice President (North-Central):	Dr. J. M. Mafwalai Federal College of Education (Tech), Pankshin, Plateau State
Vice President (North-West):	Ali Mamman Yaro Kaduna Polytechnic, Kaduna, Kaduna State
Vice President (South-East):	
Vice President (South-South):	
Vice President (South-West):	Jimba, N. I. Tai Solarin University of Education, Ogun State
Auditor I:	Dr. A. S. Garba Abubakar Tafawa Balewa University, Bauchi, Bauchi State
Treasurer:	Dr. A. M. Agada College of Education, Oju, Benue State
Financial Secretary:	Dr. A. O. Keleoso Tai Solarin University of Education, Ogun State
Public Relations Officer:	Dr. H. Angulu Abubakar Tafawa Balewa University, Bauchi, Bauchi State
Ex – Officio I:	Prof. R. O. Okwori Federal University of Technology, Minna, Niger State
Editor – in – Chief:	Prof. A. M. Hassan Federal University of Technology, Minna, Niger State
Deputy Editor– in – Chief:	H. R. Sai Kaduna Polytechnic, Kaduna, Kaduna State
General Secretary:	Dr. B. A. Wakili Federal College of Education (Technical), Potioskum, Yobe State.
Asst. General Secretary:	Dr. M. S. Sumaila Federal College of Education (Technical), Bichi, Kano State

38TH ANNUAL NATIONAL CONFERENCE OF TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (FORMERLY NIGERIAN ASSOCIATION OF TEACHERS OF TECHNOLOGY, NATT)

ACKNOWLEGEDMENTS

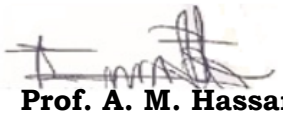
PREFACE

ABUJA 2025 is the 38th edition of the Technology Education Practitioners Association of Nigeria (formerly, Nigerian Association of Teachers of Technology) Annual National Conference and the association's Annual General Meeting (AGM). The essence of this conference is to establish a place where technical teacher educators, TVET experts, educational administrators, industry experts, government agencies and other academic researchers brainstorm and chart a way forward on improving the TVET and technical teacher educational systems in Nigeria.

Keynote speech comes up on the occasion of the conference opening ceremony. Lead paper presentations from leaders in various fields are normally scheduled at the beginning of each conference day's activities and during the lunch break. Exhibitions from various companies in the industry and the conference sponsors are show cased at the conference premises throughout the event. Last segment of the conference marks the peak of events featuring the dinner banquet in the evening and Annual General Meeting the following morning. Since inception, TEPAN (formerly NATT) Annual National Conference and Annual General Meeting holds regularly at different locations in the country after a fair bid for hosting right. At the conference, tutorials, technical paper sessions, and panel discussions are scheduled on various topics and subject areas within TVET and Technology Teacher Education. Over the years focus areas included Educational Infrastructure, Innovative Approaches to TVET, Global Economic Depression and Insecurity as they impact on educational administrative processes.

The Executive Council of the Technology Education Practitioners Association of Nigeria under the leadership of Prof. A. S. Bappah chose the theme of the 38th Annual National Conference of the association as ***Utilization of Digital Skills and AI on TVET for Economic Diversification in the 21st Century Educational Landscape***. This year's conference is hosted at the Dr. Gambo Hamza Hall, Permanent Site, FCT COE, Zuba, Abuja. Therefore, it is my pleasure to present to you **ABUJA 2025** Book of Proceedings as an invaluable reference material based on the following sub-themes: *Entrepreneurship Technology, Electrical/Electronics Technology, Wealth Job Creation, Construction Technology, Mechanical Technology, Automobile Technology, Mechantronic Technology, Content Development Technology, Design and Innovation Technology, Agricultural Technology, STEM, Business Technology, Home Science Management Technology, Private Public Partnership, Instructional Delivery Technologies, Agricultural Education, Home Economics, Fine and Applied Arts, and Business Education.*

Finally, we are most sincerely express our gratitude to all participants and our sponsors for partnering with TEPAN to blend outputs from academic researches, reports, industrial experiences and lessons learned in the field implementations and cutting-edge technologies. Our special thanks go to the Local Organizing Committee for its valuable time and effort for making **ABUJA 2025** a success.



Prof. A. M. Hassan
Editor – in – Chief


TEPAN
TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (TEPAN)
Programme of Events of
38th Annual National Conference
ABUJA 2025
THEME:
Utilization of Digital Skills and TVET for Economic Diversification in the 21st Century Educational Landscape
Date: Tuesday 8th July, 2025
Venue: Dr. Gambo Hamza Hall, Permanent Site
F.C.T COE Zuba, Abuja
Time: 9:00am Prompt



National Anthem

Nigeria, we hail thee,
Our own dear native land,
Though tribe and tongue may differ,
In brotherhood, we stand,
Nigerians all, and proud to serve
Our sovereign Motherland.

Our flag shall be a symbol
That truth and justice reign,
In peace or battle honoured,
And this we count as gain,
To hand on to our children
A banner without stain.

O God of all creation,
Grant this our one request,
Help us to build a nation
Where no man is oppressed,
And so with peace and plenty
Nigeria may be blessed.

National Pledge

I pledge to Nigeria my country,
To be faithful, loyal and honest
To serve Nigeria with all my strength,
To defend her unity
And uphold her honour and glory,
So help me God. (Amen)

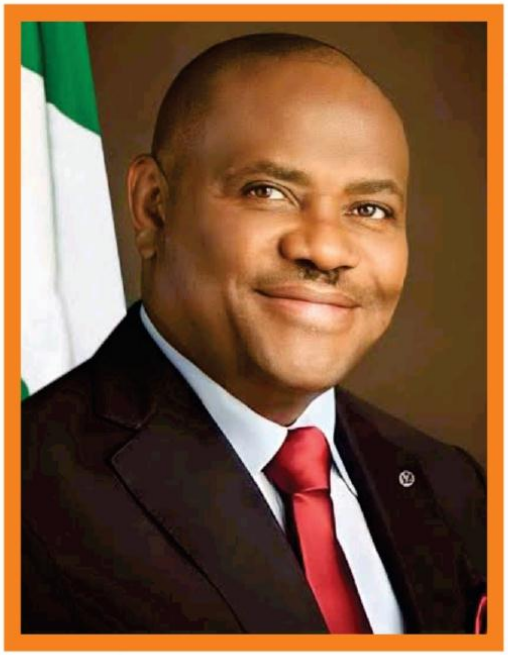
TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (TEPAN)
38th Annual National Conference

Abuja 2025



His Excellency
BOLA AHMED TINUBU, GCON
PRESIDENT COMMANDER-IN-CHIEF OF ARMED FORCES
FEDERAL REPUBLIC OF NIGERIA

TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (TEPAN)
38th Annual National Conference
Abuja 2025



EZENWO NYESOM WIKE CON
HONOURABLE MINISTER
FEDERAL CAPITAL TERRITORY

TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (TEPAN)
38th Annual National Conference

Abuja 2025



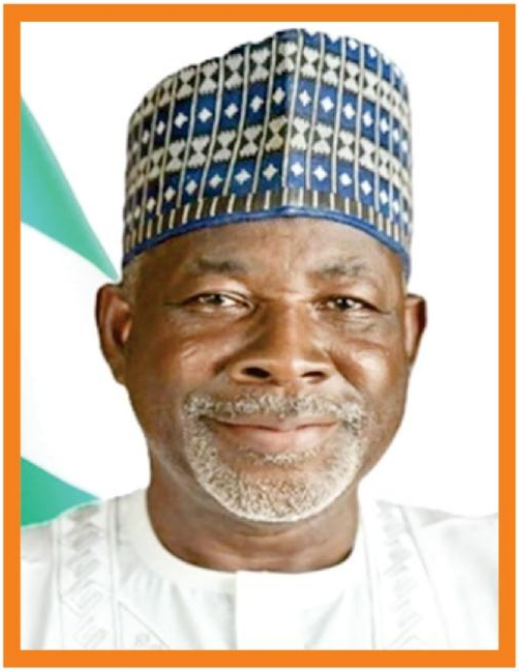
DR. SULE MUNDI
PROVOST
FCT COLLEGE OF EDUCATION ZUBA, ABUJA

TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (TEPAN)
38th Annual National Conference
Abuja 2025



PROF. A.S. BAPPAH
NATIONAL PRESIDENT
TECHNOLOGY EDUCATION PRACTITIONERS
ASSOCIATION OF NIGERIA (TEPAN)

TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (TEPAN)
38th Annual National Conference
Abuja 2025



PROF. SHEHU A. MA'AJI
MANAGING DIRECTOR
NORTH-WEST DEVELOPMENT COMMISSION
CHAIRMAN OF THE OCCASION

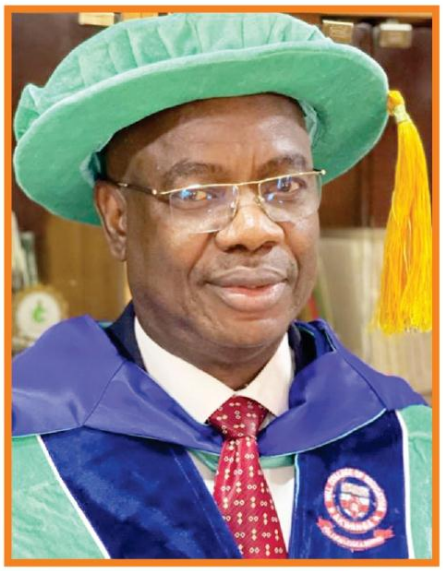
TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (TEPAN)
38th Annual National Conference
Abuja 2025



PROF. IDRIS M. BUGAJE
EXECUTIVE SECRETARY
NATIONAL BOARD FOR TECHNICAL EDUCATION (NBTE)
SPECIAL GUEST OF HONOUR

TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (TEPAN)
38th Annual National Conference

Abuja 2025



PROF. PAULINE CHIJIOKE OKWELLE MNAE
EXECUTIVE SECRETARY
National Commission for Colleges of Education (NCCE), Abuja
KEYNOTE PRESENTER

TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (TEPAN)

38th Annual National Conference

Abuja 2025



PROF. T. M. SABA

LEAD PAPER PRESENTER I

Federal University of Technology Minna, Niger State



PROF. JOY O. NWOKOLO-OJO

LEAD PAPER PRESENTER II

Benue State University Makurdi, Benue State

TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (TEPAN)

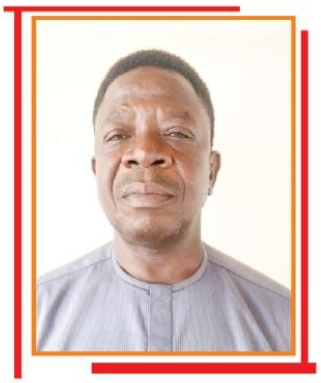
38th Annual National Conference

Abuja 2025



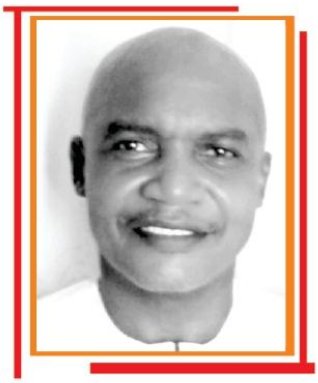
DR. RITA ONYEIZU

DEAN, SCHOOL OF VOCATIONAL AND TECHNICAL EDUCATION
FCT COLLEGE OF EDUCATION ZUBA, ABUJA
HOST



DR. LONGSHAL WAKILI

LOC CHAIRMAN
FCT College of Education Zuba, Abuja



DR. LAWAL LAMIDI

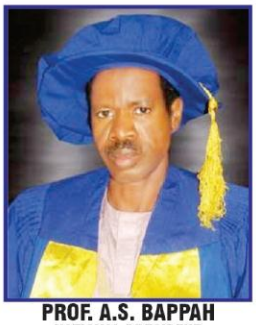
LOC SECRETARY
FCT College of Education Zuba, Abuja

TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (TEPAN)

38th Annual National Conference

Abuja 2025

TEEPAN OFFICIAL



PROF. A.S. BAPPAH
NATIONAL PRESIDENT
Abubakar Tafawa Balewa University Bauchi, Bauchi State



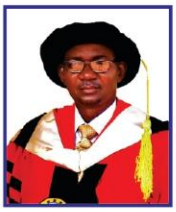
Dr. B. A. Wakili
National General Secretary
Federal College of Education (Technical) Potiskum, Yobe State



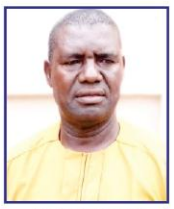
Dr. Nathanieal Nguuna Afaor
Deputy National President
Benue State University Makurdi, Benue State



Dr. A. M. Agada
Treasurer
College of Education Oju, Benue State



Dr. Haruna Angulu
Public Relation Officer
Abubakar Tafawa Balewa University Bauchi



Prof. R. I. Okwori
Ex-Offio I
Federal University of Technology Minna, Niger State



Dr. A. O. Keleoso
Financial Secretary
Tai Solarin University of Education, Ogun State

TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (TEPAN)
38th Annual National Conference

Abuja 2025

TEEPAN OFFICIAL



Ali Mamman Yaro
Zonal Vice President, North-West
Kaduna Polytechnic Kaduna, kaduna State



Dr. A. S. Yaro
Zonal Vice President, North-East
Abubakar Tatari Ali Polyctechnic Bauchi, Bauchi state



Dr. J. M. Mafawalai
Zonal Vice President, North-Central
Federal College of Education (Technical) Pankshin, Plateau State



Jimba N. Israel
Zonal Vice President, South-West
Federal College of Education (Special) Oyo, Oyo State



Prof. A. M. Hassan
Editor-in-Chief
Federal University of Technology Minna, Niger State



Haruna R. Sa'i
Deputy Editors-in-Chief
Kaduna Polytechnic, Kaduna State



Dr. Mustapha Sani Sumaila
Asst. General Secretary
Federal College of Education (Technical) Bichi, Kano State



Dr. A. S. Garba
National Auditor I
Abubakar Tafawa Balewa University Bauchi



TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (TEPAN)
38th Annual National Conference



TECNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (TEPAN)
AND
FCT COLLEGE OF EDUCATION, ZUBA-ABUJA
SCHOOL OF VOCATIONAL AND TECHNICAL EDUCATION
38TH ANNUAL NATIONAL CONFERENCE – ABUJA 2025
THEME: UTILIZATION OF DIGITAL SKILLS AND AI ON TVET FOR ECONOMIC DIVERSIFICATION IN THE 21ST CENTURY EDUCATIONAL LANDSCAPE
OPENING CEREMONY; PROGRAMME OF EVENTS 8TH JULY, 2025

S/NO.	TIME	EVENTS
1	9:30-9:55am	Arrival of students, participants/Members and invited guests.
2	9:55-10:00am	Arrival of Provost and other Dignitaries.
3	10:00am	National Anthem.
4	10:03am	Opening prayer.
5	10:03-10:10am	Introduction of guests at the high table.
6	10:10-10:20am	Welcome Address by the National President of TEPAN; Prof.A.S. Bappah.
7	10:20-10:35am	The Provost Address
8	10:35- 10: 40am	Declaration of the conference open by the Chairman of the Conference- Prof. Shehu A. Ma'aji MD Northwest Development Commission
9	10:35 -10:40am	Citation of the Key Note Address Presenter: Prof. Pauline Chijioke Okwelle Executive Sec. National Commission of Colleges of Edu. (NCCE), Abuja
10	10:40-11:00am	Key Note address Presentation: Prof. Pauline Chijioke Okwelle
11	11:00- 11:05am	Citation of the Lead paper Presenter 1 Prof.T.M Saba- H.O .D Industrial & Technology Edu.Federal University Of Technology, Minna
12	11:05-11:40am	Lead paper 1 presentation
13	11:40-11:50am	Music Interlude by the College Cultural Troops.
14	11:50-11:55am	Citation of the Lead Paper presenter 2 Prof. Joy Obiageli Nwokolo-ojo, H.O.D Dept. of Voc. & Tech. Edu. BSU Makurdi.
15	11:55 – 12:30pm	Lead paper 2 presentation
16	12:30 – 12:45pm	Goodwill Message from the Special Guest of Honour, The Executive Secretary NBTE; Prof. Idris M. Bugaje
17	12:45 – 1:00pm	Goodwill Message from the Guest of Honour, DVC Phoenix University Agwada, Nasarawa State Prof. Adamu Alhaji Mohammed
18	1:00-1:15pm	Goodwill Message from Deputy Director Federal Ministry of Education; Dr. Okoye Celestine
19	1:15- 1:30pm	Award Presentation.
20	1:30-1:40pm	Interactions, questions and answers/Responses.
21	1:40-1:50pm	Vote of Thanks by L.O.C Chairman-Dr. Longshal, M. Wakili
22	1:50-1:55pm	Closing prayer.
23	2:00pm	Closing! Closing!! Closing!!!


TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA
TEPAN

Proceedings of the 38th Annual National Conference of

Technology Education Practitioners Association of Nigeria

(Formerly Nigerian Association of Teachers of Technology, NATT)

Utilization of Digital Skills and AI on TVET for Economic Diversification in the 21st Century Educational Landscape

SUB – THEMES:

- **Entrepreneurship Technology**
- **Electrical/Electronics Technology**
- **Wealth Job Creation**
- **Construction Technology**
- **Mechanical Technology**
- **Automobile Technology**
- **Mechantronic Technology**
- **Content Development Technology**
- **Design and Innovation Technology**
- **Agricultural Technology**
- **STEM**
- **Business Technology**
- **Home Science Management Technology**
- **Private Public Partnership**
- **Instructional Delivery Technologies**
- **Agricultural Education**
- **Home Economics**
- **Fine and Applied Arts**
- **Business Education**

TABLE OF CONTENTS

Content	*Page*
TITLE PAGE	i
COPYRIGHT PAGE	ii
ATEPAN EDITORIAL BOARD	iii
TEPAN EXECUTIVE COUNCIL	iv
PREFACE	v
PROGRAMME OF EVENTS	vi
SUB–THEMES	xxi
TABLE OF CONTENTS	xxii
NATIONAL PRESIDENT'S WELCOME ADDRESS	xxxii
CHAIRMANS OF THE OCCATION WELCOME ADDRESS	xxxiii
KEYNOTE ADDRESS	xxxv
LEAD PAPER	xlvii
SUB-THEME (1): Entrepreneurship Technology	
Integrating Digital Literacy and Artificial Intelligence in Technical and Vocational Education and Training (TVET) for Sustainable Economic Diversification in the 21st Century **Nnaemeka Martin Agbo[1], Anthony Osinachi Okorafor[2] & Samson Onyeluka Chukwuedo[3]**	1-10
Leveraging Nigeria's Unemployment Crises Through Artificial Intelligence-Driven Skills For Economic Transformation **Ogbondah N. CHUKUIGWE, Dr. Baritule P. SAUE, Chidi E. EBERE & Dr. Ekwueme ORIKOHA**	11-18
SUB-THEME (2): Electrical/Electronics Technology	
Li-Fi Electro-Tech Wireless Communication For Revolutionizing Information Transmission In Oil/ Gas Field Operation Among IOCs **Eric Nwabueze Ogbuji and Christian Okwukwu**	20-26
Assessment Of Digital Pedagogical, Information And Communication Skills Competency Required By Electrical/Electronic Technology Lecturers For Effective Instructional In North-East Nigeria's Colleges Of Education (Technical) **MBAGA, Emmanuel Vandi, DAUDA, & Moses ANJILI, Tanimu**	27-37
Leveraging AI-Powered Simulation Tools to Enhance Practical Competence in Building Technology and Electrical/Electronics Technology TVET Programs in Nigeria **Onatere-Ubrurhe, Joyce Ogheneruona**	38-49
Digital Skills Requirement of Electrical / Electronics Technology Graduates for Economic Diversification in the 21st Century Educational Landscape in Rivers State. **Prof. P. C. Okwelle, Agwi Vincent I. A. Ph.D & Law-Obi Fidelia Nwanneka**	50-61

TABLE OF CONTENTS

Content	*Page*
Integrating Artificial Intelligence Digital Skills and Intelligent Systems in Electrical/Electronic Trades in Technical Colleges in Rivers State **Tambari Mtormabari DEEBOM (PhD) & Charity Bubelebara Okardi**	62-70
Effect of Electric Machine Winding Intelligent Tutor (EMWIT) on Students' Achievements and Performances in Studying Re-Winding of Three-Phase Squirrel Cage Induction Motor in Nigeria **Ezekoye, Benadeth N., Ph.D. & Ogwo, Benjamin A., Ph.D.**	71-85
Application Of Artificial Intelligence In Teaching And Learning Of Electronic Technology In Colleges Of Education In Nigeria **GARBA Zakariya'u, MUHAMMAD MUHAMMAD Bodinga & KABIRU Muhammed**	86-91
Utilization Of Digital Skills And Artificial Intelligence For Teaching And Learning Of Electrical/Electronics Technology For 21st Century Economic Development **Afaor, Nathaniel Nguuma PhD., Ajula, Matthew Ter., Jato, Solomon Daniel., and Jacob Terzulum Dura**	92-101
Evaluation Of An Intelligent Tutoring System For Teaching Basic-Electronics Concepts In Technical Colleges In South-West, Nigeria **Akindele, N. A., Soetan, A. K**	102-110
Modelling the Determinants of Hypermedia Instructional Resource Adoption in Teaching and Learning Digital Electronics in Northern Nigerian Universities **Abdulaziz Bello, Ahmad Aliyu Deba, Paul Shehu Yaduma, and Sa'adatu Abubakar Mohammed, Mustapha Nasiru, Isyaku Muhammad Bello, Abdurrahman Umar Dikko**	111-119
Exploring AI-Based Innovations in Power Systems and Infrastructure Technology: A Study on Nigerian Economic Development Through Utility Provider and Consumer Insights **[1]Jimba Nyizo Israel, [2]Oloso, Sururat E. (Ph.D), [3]Lasisi, Basiru Toyin (Ph.D), [4]Adedeji, Soji Aderemi (Ph.D) & [5]Yohanna Obadiah C.**	120-133
Integrating Artificial Intelligence (Ai) Tools in Teaching Basic Electricity Concept in University of Ilorin. **Sanni, Tunde Abdulrahman and Owodunni, Samuel Ayanda**	134-142

SUB-THEME (3):
Wealth Job Creation

Assessing The Impact Of Industry Collaboration On The Employability Of Tvet Graduates In Nigeria 144-152
Prof. I. Ogundu & Dr. N. A. Njoku

Enhancing Career Engagement And Employability Among Technical College Students Through Digital Skills And Ai For Economic Diversification 153-167
Oladiran Stephen OLABIYI, PhD.

Perceived Impact of Digital Technology Utilization on Trouble-Shooting Skill Enhancement among Students in Electrical Electronic Trades in Technical Colleges 168-175
Dr. Ukelabuchi Iloma and Precious Chikobi Osoh

Leveraging Digital Skills And AI For Entrepreneurial Innovation In Tvet: Pathway To Wealth And Job Creation In The 21st Century 176-183
[1]Shodeinde A. O., [2]Ganthonu J.O., [3]Adekunle O.A.,[3]Ajala O.S., & [4]Ogunnowo T.A

Project And Resource Management Competencies For Sustainable Job Creation In Wood-Based Micro And Small-Scale Enterprises In Nigeria 184-194
Shuaibu Saminu[1], Hassan A.M.[2], Kareem W.B.[3] Mohammed B.M.[4]

SUB-THEME (4):
Construction Technology

Developing a Digital Training Framework for Technical Vocational Education and Training (TVET) in Nigeria: Leveraging Construction Technologies for Sustainable Workforce Development 196-211
Onatere-Ubrurhe, Joyce Ogheneruona, Ugworji, Chrisjoy Tobechukwu, & Uchegbu, Chima Chidiebere

Role Of Technological Innovations In Ensuring Safety Standards In Nigeria's Construction Industry 212-218
Odesanmi Atinuke

Digital Skills Needed By Building Technology Graduates For Global Competitiveness In Construction Industry In Oyo State 219-226
Dr. Amos Aderemi AYOOLA

Integrating Digital Skills In University Woodwork Technology Curriculum For Digital Economy Development In Southwest Nigeria 227-237
Dr. Ibukun Francis ADEAGBO

Effect Of Ai-Enhanced Hybrid Wood Finishing Techniques On The Appearance And Durability Of Lecture Theatre Furniture In Benue State Tertiary Institutions 238-245
ALAKI Sunday

Harnessing AI-Driven Digital Skills in Building and Woodwork Technology Education for TVET Graduates: A Pathway to Economic Diversification and Sustainable Industrial Growth in Emerging Economies 246-257
[1]Okeowo Rebecca Oyenike, [2]Ayeoribe Toyin, S., [1]Okeowo Odunayo Sunday & [1]Adewuyi, Babajide Adetunji

Artificial Intelligence-Based Defect Detection Systems For Enhancing Quality Control In Nigeria's Construction Industry 258-267
[1]ALHASSAN Usman Ndagi, PhD, [2]ARAH Abubakar Saidu PhD & ISAH Yahaya PhD

Building Information Model in Nigeria Construction Industry: Benefits and Barriers 268-273
Dr. C.O. Igwe[1], Tsado, Elisha Garba[2], Dr. Ogbonna, Emeka[3] K. & I.S. Enagi[4]

Development of Computer Numerical Control Woodworking Machines Content for Integration into Nigeria Certificate in Education (Technical) Curriculum 274-281
Hassan S.,[1] Tadnum, Y. M.,[2] Saulawa, B. U.,[3] Hamza, S.,[4] Angulu, H.,[5] and Chedi, J. M.,[6]

Development of Building Information Modelling Course Content for Inclusion in Building Technology Minimum Standard in Colleges of Education in Nigeria. 282-293
Tijjani, Aminu[1] Dauda, I.[2], Kagara, A. B.[3], Okwori R. O.[4]

Evaluating The Professional Development Needs Of Building Technology Educators In The Application Of Artificial Intelligence For Building Drawing In Technical Colleges Of FCT, Abuja 294-305
[1]Mukaila Abiodun Yisa, [2]Sodehinde, Abidemi .O. [3]Raji, Farouk Abiodun, & [4]Abd - El - Aziz, A. Adekunle

Influence Of 3D Building Modeling As An Instructional Tool On Students' Academic Performance In Building Technology In Technical Colleges Of Niger State 306-311
[1]Raji, Farouk Abiodun, [2]Lemo, Olusiji Olaseni, [3]Fadairo, Oriola Olatunji, [4]Bolatito, Mathew Olatunde, & [5]Shosanya, Abuldrasheed Oluwatobi

Enhancing Teaching And Learning Of Technical Drawing Through Artificial Intelligence Tools In Technical Colleges In Niger State 312-319
[1]Binni Danjuma Beji PhD., [2]Dr. Akinduro Ifeoluwa Reuben & [3]Dr. Umar Muhammad Ahmad

SUB-THEME (5):
Mechanical Technology

Mechanical Technology And It Funding For Sustainable Development In The 21st Century 321-328
Akpaka Stephen Andrew PhD

Misconceptions Among Metalwork Trade Students In Government Technical Colleges In Kano State: Tracking Misconceptions Using ChatGPT 329-335
Abubakar Adamu Njibulwa

Utilization Of Artificial Intelligence In Mechanical Technology Education Programmes For Sustainable Employability Skill Development In Tertiary Institutions In Rivers State 336-342
[1]Ajie, Prince Maduabuchukwu (Ph.D), [2]Ojobah, Lucky Obulor (Ph.D), & [3]Okirie Ogaranya

Challenges In Adopting Artificial Intelligence For 21st Century Skill Acquisition Of Mechanical Technology Education Students' In Tertiary Institutions In Rivers State 343-349
[1]Ajie, Prince Maduabuchukwu (Ph.D), [2]Otoboh, Christian Obi; [3]Eluozo, Progress Ozioma, & [4]Ogbanga, Ibifuro

Teachers' Readiness To Utilize Artificial Intelligence In Implementating Motor Vehicle Mechanic's Work Curriculum In Federal Capital Territory, Abuja, Nigeria 350-358
[1]JUTUM Joel Isiah; [2]ARAH Abubakar Saidu PhD & [3]BINNI Danjuma Beji, PhD

SUB-THEME (6):
Automobile Technology

The Extent of Utilization of Digital Skills and Artificial Intelligence Tools for Effective Diagnosing of Automobile Systems Among Technicians in Benue State 360-367
Orbula Joshua Tertsegha, Jacob Ibrahim, & Danjuma Adamu

Skills Required By Automobile Technology University Graduates In Diagnosing Auto-Electrical Faults In Motor Vehicles In Edo State, Nigeria 368-376
Dr. S.O. Osuyi & F.O. Aizebeoje

Automobile Technology Education For Sustainable Development: Advocacy And Education 377-383
Ukuma Solomon, Ph.D & DEKE, Nyitar Gabriel

Competency Improvement Needs of Craftsmen in Motor Vehicle Mechanic Work for enhancing Employ-ability in Automobile Industries: An evidence from Nigeria 384-390

Mukaila Abiodun Yisa

SUB-THEME (7): Content Development Technology

Promoting indigenous knowledge in education, science and technology in tertiary institutions 392-398

Robert O. Okwori CLN[1] & Elizabeth A.Okwori[2]

Information and Communication Technology Interaction and Language through Computational Terminology 399-405

BELLO, Yekeen

SUB-THEME (8): Agricultural Technology

Entrepreneurial Skills Required by Agricultural Education Students in Tertiary Institutions in Kano State for Optimal Success in Sheep Husbandry Practices 407-416

Idi Garba, PhD

Assessing The Effectiveness Of Digital Skills Integration In Agricultural Education For Economic Diversification In Delta State 417-427

Iyeke Aghogho Perculiar, Ph.D.

Influence Of Collection Time On Nutrients And Microbial Loads Of Some Frozen Marine Fish Species Sold In Bichi Local Government Area Of Kano State, Nigeria 428-442

Kasim Lawal Ibrahim

Urban Silvopastural Agroforestry: Integration Of Snail Production Strategy For Combating Food Insecurity 443-448

Ogunsusi, Kayode

Administration of Bridelia ferugenea (Benth) leaves extract regulates pro-inflammatory cytokines and DPP4 mRNA in hepatic tissue of diabetic model rats. 449-454

Cecilia Oluwamodupe

Effect Of Breed On Growth Pattern Of Broiler Chicken 455-460

Olubisi O. Oyeleye*, Adelani A. Adeoye and Fayokemi O. Akosile

SUB-THEME (9):
STEM

Utilization of Digital Skills and AI on Biology Education for Diversification in the 21st Century Educational Landscape 462-465
Amina Othman Zakari

Artificial Intelligence and Digital Technologies: Catalysts for Innovation in Pure and Applied Chemistry for Economic Diversification in Nigeria 466-477
Maryam Dapo Aniara

Digital Skills and AI Utilization in Nigeria's TVET System: A Panacea for Economic Diversification in the 21st Century Educational Landscape 478-485
Isaac, U. C. N., PhD & Owo, O. T. PhD

Emerging Trends In Robotics And Artificial Intelligence On Curriculum Development In Stem Education: Preparing Students For Future Security And Technological Innovations 486-506
Prof. Peter Ashlame Agu and Dr. Iwanger Ruth Samuel

Gamification and Game-based Learning for Fostering Critical Thinking in Physics Education: Strategy to Revitalize the Nigeria Education Landscape 507-516
Prof. Anikweze, Charles Maduegbuna & Dr. Kanu, Abednego Chibuzo

Utilisation Of Digital Skills And Artificial Intelligence (AI) On TVET For Economic Diversification In 21st Century Education Landscape In Nigeria 517-525
Shamsuddeen Ibrahim Umar PhD

Exploring The Availability, Accessibility, And Utilization Of Computer And Internet Resources Among Chemistry Undergraduate Students In Kano State 526-535
[1]Kasim Ibrahim Mohammed, [2]Dr. Abubakar Zubair Yushau, [3]Salisu Muhammad Aliyu, & [4]Ishaq Mohammed Aliyu

SUB-THEME (10):
Business Technology

Exploring the Integration of Digital Skills and Artificial Intelligence (AI) in Business Education: Implications for 21st Century 537-545
Inalegwu.O. Mary

Perceived Influence Of Marketing Strategies On Organizational Performance Of Small And Medium Scale Enterprises In Maiduguri Metropolis, Borno State 546-555
Modu Korimi[1] and Mohammed Goni Tela[2]

556-566

Integrating Artificial Intelligence into Teaching Business Education Subjects: Enhancing Learning and Entrepreneurship in Ramat Polytechnic, Maiduguri
***[1]Mustapha Ali, [2]Bashehu Saleh and [1]Mohammed Goni Tela**

SUB-THEME (11):
Home Science Management Technology

Investigating Benefits And Challenges Of Food Storage Patterns Practiced By Home Makers In Ondo West Local Government Area Of Ondo State 568-576
[1]Bello, M., [2]Olarewaju, C.A, Adeyanju, B. E.& [3]Folorunsho F. E.

Impact of Utilizing Digital Skills in Automobile through AI for Economic Diversification in Technology Education 577-587
Orie, Chukwulenwenwa John & Daniel Chukwulenwa Onyije

Enhancing Attractiveness of Technical Education Degree programme Amongst Students Seeking Admission into Universities in Rivers State 588-603
Ekeukwu Pureheart Ocebe-Tani-Dininye-Nkoma

SUB-THEME (12):
Private Public Partnership

The Effect Of Road Transportation Infrastructure On Economic Growth In Nigeria 605-615
Alhassan Yunusa Alkali & Hassan Gimba Suleiman

Regular School Community Engagement; Paradigm For Development Of Technical And Vocational Education In Ogba/Egbema/Ndoni Local Government Area, Rivers State 616-627
Ekeukwu Pureheart

SUB-THEME (13):
Instructional Delivery Technologies

Gamification in Education: A systematic review of literature on Kahoot, Quizizz and Quizlet and Implementation in Nigeria. 629-639
OLADOSU, Kamaldeen Korede, GAMBARI, Amosa Isiaka, KUTA, Ibrahim Ismaila, OJENIYI, Joseph Adebayo

Teachers' Capacity Building On Intelligent Tutoring System For Instructional Delivery In Technical Colleges In Kwara State 640-650
Taiwo, S. A., Akindele, N. A., Owodunni, A. S.

Impacts Of Artificial Intelligence Training And Upskilling For Industrial Technology Education Lecturers' Effectiveness In Nigeria For Industry 4.0 And Beyond 651-663
Ugwunali Yannick Chidi, & Okorieocha Christopher Ndudi, Ph.D.

Multimedia Integration And Its Impact On Learning In And Outside The Classroom 664-671
IBIRONKE, Ebenezer Sanya, HASSAN A. M, & ADEROJU, Musiliu Adekola

Impact Of Collaborative Apps On The Performance Of Blind Students In Special Needs Schools In Ilorin Metropolis 672-679
[1]Soetan. A. K., [2]Adewoye. F. T., [3]Usman M., and [4]Oyebanji. B. R.

Undergraduates' Attitude Towards The Use Of Artificial Intelligence In Learning In University In Ilorin, Nigeria 680-685
[1]Soetan. A. K., [2]Usman M and [3]Oyebanji B. R.

Ethical Challenges of Integrating AI into Technology Education Assessment 686-690
NUFFI, O.Jonathan PhD

Influence Of Algorithm-Based Instructional Methods On Students' Academic Achievement And Interest In Basic Technology 691-701
[1]Dr. Umar Muhammad Ahmad, [2]Nathaniel Jibrin Usman & [3]Zhiri Deborah

Perception of Virtual Reality as an Instruction Tool among Preservice TVET Teacher Educators in Tertiary Institutions in Rivers State 702-712
***[1]Legborsi Nwineh (PhD), [2]Ekwueme Orikoha (PhD) and [3]Kelechi Casmir Ezinma**

Assessment Of Basic Technology Teachers' Awareness And Use Of Artificial Intelligence In Classroom Instruction In Secondary Schools In Minna, Niger State 713-720
[1]Abdullahi Muhammad Hassan, [2]Roseline Yusuf Karfe, & [3]Chinyere Geraldine Ugwunnagu

Evaluation Of Teachers' Implementation Strategies Of The Basic Science And Technology Curriculum In Junior Secondary Schools In Niger State 721-731
[1]Salihu Danladi Alhaji, [2]Usman Ibrahim Adamu and [3]Ibrahim Ya'u

SUB-THEME (14):
Home Economics

Consumption Of Fruits, Vegetables, Snacks, And Sugar-Sweetened Beverages Among Undergraduate Students Of Ondo State University Of Science And Technology 733-739
[1]Olarewaju, C.A., [2]Bello, M., & [3]Oghen, F. M.

Sociocultural Influences On The Eating Behaviours Of Adolescents In Ondo East Local Government Area Of Ondo State 740-750
Oseyemi Esther AKINYOTU(Ph.D.)

Digital Literacy and the Enhancement of Food Safety Education in Technical Schools in Rivers State: A case of Federal College of Education, Technical, Omoku 751-762
Dibia-Emmanuel, Nkasimobu, C. Ph.D

Assessment Of Students Academic Performance In Technical Drawing In Government Science And Technical Colleges Yobe State 763-772
Bala Adamu Wakili

Project-Based Learning Conceptual Model For Non-Technical Skills Of Electrical Installation And Maintenance Work Students In Technical Colleges In North-West, Nigeria 773-786
Ibrahim, Y., Saba, T M., Owodunni A S. and Raymond E

Artificial Intelligence (AI) As A Means Of Promoting Technical And Vocational Education TVET For Economic Diversification In Nigeria 787-794
Atika Faruk Garba

WELCOME ADDRESS BY NATIONAL PRESIDENT OF TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (FORMERLY NIGERIAN ASSOCIATION OF TEACHERS OF TECHNOLOGY)

PROFESSOR ABUBAKAR SADIQ BAPPAH FNATT, MNAE, MNSE, MIEEE, COREN

AT THE OPENING CEREMONY OF THE 38TH ANNUAL NATIONAL CONFERENCE OF THE ASSOCIATION AT DR. GAMBO HAMZA HALL, PERMANENT SITE, FCT COE, ZUBA, ABUJA ON TUESDAY 7TH JULY, 2025

Protocols

Distinguished guests, respected colleagues, ladies and gentlemen

It is my pleasure to welcome you all to the 38th Annual National Conference of the Technology Education Practitioners Association of Nigeria (TEPAN) formerly called Nigerian Association of Teachers of Technology (NATT). I sincerely appreciate the Almighty God for granting us a safe trip to Abuja, the Federal Capital of Nigeria. I am delighted to welcome you to this Opening Ceremony holding here today at this great and dynamic College.

We sincerely appreciate the presence of the distinguished personalities here who have made the sacrifice to create time to grace this annual occasion of the Association. Today, we are privileged to have the Chairman of the occasion. I want to specially recognize the enthusiasm of our envoys who bided and secured us the permission to hold this conference here.

We sincerely appreciate the members of the Local Organizing Committee for their relentless effort that made this conference a reality. We are also grateful to have the former Presidents, Fellows of TEPAN, Professors, other dignitaries and all our academic fathers and leaders here today for ABUJA 2025 TEPAN Annual National Conference.

The theme of the 38th Annual National Conference of the Association is **"UTILIZATION OF DIGITAL SKILLS AND AI ON TVET FOR ECONOMIC DIVERSIFICATION IN THE 21ST CENTURY EDUCATIONAL LANDSCAPE"** has been chosen after careful deliberation, to reflect the fact that there have been fundamental changes to both the nature and the dynamics of the world. This may in turn affect the way the industry addresses the challenges that lie before it. The post Covid 19 New Normal seeks is characterized with emerging trends in harnessing TVET which, if mastered wisely, create sustainable global opportunities.

During this conference, these and many other topical issues that relate to the day-to-day sustainable development in the years ahead will be discussed. We shall benefit from the great strides that have been contributed since the 20th century and as well supported the sustainable development. Indeed, we expect such collaboration to continue in the future by fully utilizing the latest advances in technology to ensure the continued steady supply of information.

We are privileged to have in our midst, speakers who will be sharing with us intellectually in this conference. They include top officers from intergovernmental bodies, chief executives of national and international organizations and renowned academics. We are deeply appreciative of their presence despite their tight schedules to participate in this conference. We are confident that, participants will benefit from their knowledge and experiences.

Finally, since I know that our erudite scholars are keen to present their papers, we are therefore compelled to announce to you that paper presentation starts immediately the opening ceremony is over. Announcement of further adjustments in our schedule of activities will be unfolded in due course.

Long live the Federal Republic of Nigeria.

Long live ABUJA (FEDERAL CAPITAL OF NIGERIA).

Long live Technology Education Practitioners Association of Nigeria (TEPAN).

God Bless you all.

WELCOME ADDRESS BY CHAIRMAN OF THE CONFERENCE PROF. SHEHU A. MA'AJI MANAGING DIRECTOR, NORTH-WEST DEVELOPMENT COMMISSION AT THE OPENING CEREMONY OF THE 38TH ANNUAL NATIONAL CONFERENCE OF THE ASSOCIATION AT DR. GAMBO HAMZA HALL, PERMANENT SITE, FCT COE, ZUBA, ABUJA ON TUESDAY 7TH JULY, 2025

Protocols

Distinguished Guests, Esteemed Colleagues, Practitioners of Technology Education, Ladies and Gentlemen

It is with great honor and a deep sense of responsibility that I stand before you today at this landmark 38th Annual National Conference of the Technology Education Practitioners Association of Nigeria (TEPAN). I bring greetings to all of you who have journeyed from across the country and beyond to converge in our nation's capital for what promises to be an intellectually rich and practically transformative gathering.

Let me begin by commending the leadership of TEPAN for the vision and foresight demonstrated in choosing this year's conference theme: "Utilization of Digital Skills and AI on TVET for Economic Diversification in the 21st Century Educational Landscape." This theme is not only timely—it is urgent, relevant, and fundamentally critical to Nigeria's future.

The Context of Change

The 21st century is characterized by exponential technological advancements, rapid digitization, and an evolving global economy where knowledge and skills are the new currency. Artificial Intelligence (AI), automation, data science, and digital literacy are now reshaping industries, redefining job roles, and transforming the ways we teach, learn, and produce.

At the same time, Nigeria faces the pressing challenge of economic diversification. For decades, our national economy has leaned heavily on oil, a volatile and finite resource. The call for a diversified economy—anchored in innovation, skills, and productivity—has never been more urgent.

This is where Technical and Vocational Education and Training (TVET) comes in. TVET is our national engine room for practical skills, entrepreneurship, and workforce readiness. However, if TVET must play its rightful role in economic transformation, it must evolve. It must integrate digital skills and AI as foundational pillars—not as optional additions.

Why Digital Skills and AI Matter in TVET

1. Bridging the Skills Gap:

Industries are demanding a workforce equipped with digital competencies—ranging from coding, digital fabrication, cybersecurity, to AI-powered solutions. TVET institutions must respond by updating curricula, retooling trainers, and investing in digital infrastructure.

2. Enhancing Teaching and Learning:

AI-driven platforms such as intelligent tutoring systems, automated assessments, and personalized learning pathways can revolutionize how students acquire skills. These tools make education more adaptive, efficient, and accessible.

3. Job Creation and Entrepreneurship:

Digital skills empower young Nigerians not just to seek jobs, but to create them. Whether it's launching an online business, developing mobile apps, or providing digital services, the possibilities are limitless. AI adds an extra layer of innovation—enabling students to design smart products, automate processes, and solve real-world problems.

4. Global Competitiveness:

With digital and AI literacy, Nigerian TVET graduates can compete globally, not just locally. Remote work, freelancing, and global collaboration are now viable career paths for our youth.

The Role of Stakeholders

To realize this vision, all stakeholders have a role to play:

Government must fund and implement policies that support digital transformation in TVET.

Educators must continuously upskill and embrace new pedagogies.

Industry partners must collaborate with institutions to ensure relevance and alignment.

Students must be open to learning, unlearning, and relearning in this digital age.

Call to Action

Let this conference be more than a gathering of minds. Let it be a turning point—a moment when we commit to transforming TVET into a powerhouse of innovation and economic renewal.

Let us not be content with old models of training that no longer serve the present reality. Let us be bold in our pursuit of a digitally empowered, AI-integrated, and economically relevant TVET system. Let us prepare our students not just for jobs, but for futures we cannot yet fully imagine.

Conclusion

As we deliberate, collaborate, and chart a course in the days ahead, let us remember that the future of Nigeria depends not only on what is taught, but how it is taught—and how ready our youth are to drive the industries of tomorrow.

Together, let us harness the power of digital skills and artificial intelligence to build a more prosperous, innovative, and resilient Nigeria.

Thank you.

God bless TEPAN.

God bless Nigeria.

KEYNOTE ADDRESS

UTILIZATION OF DIGITAL SKILLS AND AI ON TVET FOR ECONOMIC DIVERSIFICATION IN THE 21ST CENTURY EDUCATIONAL LANDSCAPE

Professor Paulinus Chijioke Okwelle, MNAE
Executive Secretary
National Commission for Colleges of Education (NCCE), Abuja.

Keynote Address Presented at the 38th Annual National Conference organized by the Technology Education Practitioners Association of Nigeria (TEPAN) held at Multi-Purpose Hall, FCT College of Education Zuba, Abuja.

7th–11th July, 2025

Preamble

Distinguished colleagues, esteemed researchers, education policymakers, industry partners, and advocates of Technical and Vocational Education and Training (TVET), I am deeply honoured to address you today at this significant gathering, which focuses on the transformative potential of digital skills and artificial intelligence in TVET for Nigeria's economic diversification. We gather today not only to share ideas but to reflect deeply on how Nigeria can harness the immense power of technology, particularly digital skills and artificial intelligence, to transform its economy and reposition TVET for relevance in the 21st century.

We stand at a crucial moment in history. A time where the convergence of digital technologies and artificial intelligence is fundamentally reshaping every aspect of human endeavour. This conference, therefore, is timely, and I commend the organizers for choosing the conference theme, which addresses a global concern. Thank you for the opportunity to address you at this conference.

1. Introduction

In the contemporary global economy, technological innovation, particularly in digital skills and Artificial Intelligence (AI), has become a cornerstone for economic growth and diversification. Economic diversification is not merely an option but an imperative for sustainable development and resilience. Today, with major disruptions like work and workplaces across the globe, the development of learning societies that are adaptive to the increasing pace of change calls for a new paradigm in education and training. For Nigeria, a country striving to move beyond oil dependency, facing challenges in unemployment and skills mismatch, integrating digital skills and AI into education and skill development training system is a vital requirement to ensure that the skill sets of those joining the labor force support the economic strategies of the country in the 21st century.

Technical and Vocational Education and Training (TVET) is a crucial aspect of education that equips the workforce with relevant skills to foster economic diversification. The integration of digital skills and Artificial Intelligence (AI) into TVET offers promising pathways to enhance Nigeria's economic resilience and competitiveness in the 21st century. The 21st century demands not just vocational competence, but also digital fluency. Engendering a culture of learning with investments in high-quality education and skills development programmes is the key to economic success in today's knowledge-driven digital economy (Fung et al, 2021). Transforming Nigeria's TVET through digital integration is crucial for enhancing economic competitiveness and improving employability. The question posed here is: How can we harness digital skills and AI in TVET to accelerate this diversification and position Nigeria as a competitive player in the global knowledge digital economy?

As we navigate this critical conversation at this conference, I invite you to envision a future where Nigerian TVET institutions serve as innovation hubs, where learners develop not just technical competencies but digital fluency and adaptive expertise, where industry and education are seamlessly integrated, and where TVET graduates become drivers of economic transformation rather than mere job seekers. This presentation, therefore, explores the definitions, linkages, relevance, benefits, prospects, challenges, and the way forward for leveraging digital tools and AI in Nigeria's TVET sector.

2. Definition of Key Concepts and Their Interrelationships

To establish a common framework for our discussion, let us clarify the key concepts embedded in our conference theme:

2.1 *Technical and Vocational Education and Training (TVET)*

Technical and Vocational Education and Training (TVET) encompasses education, training and skills development relating to a wide range of occupational fields, production, services and livelihoods. TVET provides learners with practical skills, technical knowledge, and competencies aligned with labour market needs. It focuses on hands-on training in various trades, crafts, and emerging sectors to enhance employability and entrepreneurship (UNESCO-UNEVOC, 2021). TVET prepares individuals for specific occupations by developing practical competencies, knowledge, and understanding (Mahmood, Ali & Bilal, 2018; Okoye & Okwelle, 2014).

2.2 *Digital Skills*

Digital skills refer to the ability to use digital devices, communication applications, and networks to access and manage information (Coward & Fellows, 2018). These skills include proficiency in computer literacy, coding, digital communication, data analysis, and cybersecurity (European Centre for the Development of Vocational Training [Cedefop], 2020). In the context of TVET, digital skills encompass both the general digital competencies required in virtually all occupations and the specific technological skills needed in particular vocational domains.

2.3 *Artificial Intelligence (AI)*

Artificial intelligence refers to computer systems capable of performing tasks that traditionally required human intelligence, including learnig, reasoning, problem-solving, perception, and language understanding (Zawacki-Richter et al., 2019). It encompasses machine learning, natural language processing, robotics, and automation, transforming various sectors by enabling intelligent decision-making and automating complex tasks (Russell & Norvig, 2016). In education, AI is used in adaptive learning platforms, predictive analytics, automated assessments, and intelligent tutoring systems (Holmes et al., 2021). In TVET contexts, AI can serve as both a subject of instruction and a tool for enhancing teaching, learning, and assessment processes.

2.4 *Economic Diversification*

Economic diversification refers to the process of shifting an economy away from a single income source toward multiple sources from a growing range of sectors and markets (Anyaehie & Areji, 2015). For Nigeria, this means shifting from an oil-dependent economy to one that includes technology, manufacturing, agriculture, and services. Effective economic diversification requires a skilled workforce equipped with competencies relevant to emerging sectors.

2.5 21st Century Educational Landscape

The 21st-century landscape is characterized by the integration of digital technology, AI, globalization, and innovative pedagogies to prepare learners for a dynamic, technology-driven economy. It emphasizes critical thinking, digital literacy, lifelong learning, and adaptability.

2.6 Interrelationships among key Concepts

The interrelationships among these concepts form a dynamic ecosystem for economic transformation. The integration of digital skills and AI into TVET creates a synergistic relationship that enhances the relevance and effectiveness of vocational training. TVET serves as the primary mechanism for developing the human capital required for economic diversification. Digital skills and AI competencies represent increasingly critical components of this human capital development, as they enable innovation, productivity enhancement, and competitiveness across all economic sectors.

The integration of digital skills and AI into TVET creates a "multiplier effect," wherein digitally enhanced vocational education produces graduates who can, in turn, apply digital technologies to innovate within their respective sectors, thereby accelerating economic diversification. This virtuous cycle between TVET, digital capacity, and economic transformation represents the core rationale for our conversation today. Digital technologies and AI are also transforming the very nature of TVET delivery. They enable new pedagogical approaches such as simulation-based learning, personalized instruction, virtual laboratories, and remote mentoring (Olabiyi & Chinedu, 2025). These innovations can enhance both the accessibility and effectiveness of TVET programmes across all sub-themes of our conference.

3. Relevance of Integrating Digital Skills and AI into TVET

The integration of digital skills and AI into TVET for economic diversification holds profound significance for Nigeria's development trajectory. Nigeria's demographic dividend, characterized by a youthful population, presents an opportunity for economic growth if harnessed effectively. Therefore, incorporating digital skills and AI into TVET aligns with Nigeria's development goals, such as the Economic Recovery and Growth Plan (ERGP, 2017-2020), which emphasizes technological advancement and skills development. In a globalized economy, digital literacy and AI competencies are essential for Nigerian youths to participate meaningfully in emerging sectors like fintech, renewable energy, and digital agriculture. Let us examine several dimensions of this importance:

3.1 Addressing Youth Unemployment

Nigeria continues to face significant unemployment challenges, with more than 70% of its population under the age of 35 and an estimated 53.4% of this demographic unemployed (Federal Ministry of Budget and Economic Planning, 2022, cited in Danlami, Abdullahi, Nafi'u, & Hafsat, 2025). Although the National Bureau of Statistics (2024) reported a youth unemployment rate of 5.3% for individuals aged 15–34, this figure likely underrepresents the actual situation, as it excludes widespread underemployment and a substantial number of discouraged job seekers. This staggering figure represents not only an economic challenge but also a social and political one. A transformed TVET system that equips young people with market-relevant digital skills can help bridge the gap between education and employability.

3.2 Accelerating Economic Diversification

Nigeria's overreliance on oil revenue has led to economic vulnerability and limited job creation. According to the National Bureau of Statistics (2023), the oil sector accounts for less than 10% of Nigeria's GDP. This imbalance underscores the urgent need for diversification. Equipping learners with skills in AI and digital technologies will facilitate the growth of non-oil sectors, reducing over-reliance on oil revenues. Thus, digital skills and AI can serve as catalysts for the development of other sectors, such as agriculture, manufacturing, information technology, and services. Hence, digitalization in TVET in Nigeria can enhance productivity.

3.3 Responding to Changing Labour Market Demands

The nature of work is changing rapidly across all the sub-themes represented at this conference. According to the World Economic Forum (2016), 65% of children entering primary school today will ultimately work in jobs that do not yet exist. This underscores the need for a TVET system that not only imparts current technical skills but also develops the digital and cognitive capabilities that enable continuous adaptation and learning. Graduates with digital and AI skills are more adaptable and competitive in the labour market.

3.4 Enhancing Global Competitiveness

In an increasingly integrated global economy, Nigeria's competitiveness depends significantly on the technological capabilities of its workforce. Technological readiness and innovation capacity are critical determinants of national competitiveness. By integrating digital skills and AI into TVET, Nigeria can enhance its position in global value chains and attract investment in technology-intensive sectors.

3.5 Promoting Inclusive Development

When appropriately implemented, a digitally enhanced TVET system can promote inclusive development by expanding educational access to underserved populations. Mobile learning technologies and AI-powered educational applications can reach rural areas, persons with disabilities, and economically disadvantaged learners who might otherwise be excluded from quality vocational education. Digital tools, therefore, can broaden access to quality education, especially in underserved rural areas, promoting equitable development. This inclusivity is essential for ensuring that the benefits of economic diversification are widely shared.

3.6 Supporting Entrepreneurship and Innovation

Digital skills and AI competencies enable TVET graduates to become job creators rather than just job seekers. TVET graduates with strong digital skills are more likely to establish successful enterprises. Digital skills would enable graduates to leverage online platforms (e.g., social media, e-commerce sites) to promote and sell products or services at minimal or no cost. This broadens their market reach beyond local communities to regional, national, or even global audiences. This reduces the need for significant capital investments and improves operational efficiency. So, graduates with digital and AI skills could attract investment and foster entrepreneurship.

4 Comparative Analysis of Global Practices

To inform Nigeria's approach to integrating digital skills and AI into TVET, it will be appropriate to examine successful models from other countries, particularly those with contexts relevant to Nigeria:

4.1 Singapore:

Singapore has implemented a comprehensive national strategy called “SkillsFuture”, a national movement launched in 2015 to provide Singaporeans with the opportunity to develop their full potential throughout life, regardless of their starting point (Singapore Ministry of Education, 2022). Singapore’s "Skills Future" initiative aims to build a versatile workforce equipped with digital and AI skills. The country's Institute of Technical Education (ITE) has also developed a "Technical Skills + Digital Skills + Critical Core Skills" framework, ensuring that all vocational learners develop not only occupation-specific competencies but also digital literacy and adaptability (Cheng, 2019). Singapore's approach is characterized by:

- Strong industry-education partnerships, with companies co-designing curricula and providing work-based learning opportunities
- A national digital skills framework that clearly articulates competency standards
- Inclusive lifelong learning policies

- Continuous professional development for TVET instructors to enhance their digital pedagogical capabilities
- Strong emphasis on entrepreneurship and innovation.

Impact: Singapore's focus on digital skills has diversified its economy into fintech, biotech, and digital services, positioning it as a global innovation hub

4.2 Germany:

Germany's dual vocational education and training system, long considered a global benchmark, has evolved to incorporate digital skills and AI competencies. The country's "Vocational Training 4.0" initiative specifically aims to contribute to the implementation of the digital agenda through continuous exchange of information between academia, policy-making and practice (CEDEFOP, 2025). Institutions involved in TVET training in Germany utilize AI tools to simulate production line environments, allowing students to practice troubleshooting and operational skills without interrupting the real-world production process. This is regarded as Smart Factories for Apprenticeships (Morley, 2024). Key success factors:

- Deep industry involvement.
- Strong emphasis on certification and lifelong learning.
- Integration of AI tools for personalized training.

Impact: Germany maintains a highly skilled workforce that sustains its export-led economy and technological innovation, serving as a model of integrating AI into vocational training.

4.3 India

India's TVET sector is increasingly embedding digital literacy, digital skills, and AI-related competencies to meet the demands of Industry 4.0. Initiatives include integrating coding, data analytics, AI tools, and digital platforms into vocational curricula, with a focus on skilling youth for emerging sectors like IT, manufacturing, and services (Government of India, 2020). India's TVET institutions are adopting e-learning platforms and AI-based training tools to enhance the employability of students in rural areas (Awangku, 2025). Key success factors include:

- The development of the National Skills Development Policy emphasizes digital literacy.
- Public-private partnerships: Collaborations with tech giants (e.g., Infosys, TCS) facilitate industry-relevant training.
- The digital infrastructure expansion wish provides widespread access to digital tools and e-learning platforms.
- Updating TVET curricula to include AI and digital skills.

Impact: Improved employability in tech-driven sectors, Enhanced access to quality skills training in rural and underserved areas. Alignment of skills supply with Industry 4.0 needs, fostering innovation and entrepreneurship.

4.4 Australia

Australia's TVET (or VET) system actively incorporates digital skills and AI, emphasizing advanced tech literacy, data analytics, automation, and Industry 4.0 readiness. The system emphasizes applied learning, industry partnerships, and ongoing curriculum updates. In particular, Australia's Virtual Welding Trainers, which utilize AI, provide instant feedback to students practicing welding techniques, thereby improving their precision and reducing material waste (Morley, 2024). Key Success Factors include:

- Strong industry collaboration results in co-designed programmes, ensuring relevance.
- Government investment through funding for digital infrastructure, online learning platforms, and trainer upskilling.

- Curriculum flexibility that allows VET providers to adapt quickly to technological changes.
- Integration of emerging AI research into training.

Impact: High levels of digital literacy among students, workforce ready for Industry 4.0 and AI-driven sectors. Also, increased innovation capacity and productivity within industries.

4.5. South Korea

South Korea is renowned for its advanced technological infrastructure and innovative TVET system. The government launched the "Smart Factory" initiative in 2014 (Gwang, 2023), integrating AI, IoT, and automation into manufacturing training programmes. South Korea is considering introducing artificial intelligence as a standalone subject in elementary, middle and high school curricula (The Korea Herald, 2025). Key success factors:

- Strong government-industry partnerships.
- School curricula emphasizing AI-driven manufacturing skills, enabling students to operate and maintain smart factories.
- Continuous curriculum updates aligned with Industry 4.0.
- Investment in digital infrastructure and teacher training.

Impact: South Korea's tech-savvy workforce has powered its export-driven economy, particularly in electronics and automobiles, exemplifying how digital skills embedded in TVET foster industrial innovation.

4.6 Rwanda:

Rwanda, a developing nation, has made significant strides in leveraging digital tools and AI to rebuild its economy. Rwanda's strategic vision, including the Smart Rwanda Master Plan (2015–2020), emphasizes digital skills, AI, and innovation in TVET. The Digital Rwanda Vision emphasize ICT literacy, AI, and digital entrepreneurship, especially for youth employment and agribusiness (Rwanda Development Board, 2021). Key success factors:

- Government-led digital transformation policies.
- Integrating AI into curricula for sectors such as ICT, agriculture, and manufacturing.
- Partnerships with international donors and tech companies.
- Focus on inclusivity and rural digital access.

Impact: Rwanda's digital initiatives have improved agriculture productivity and fostered rapid workforce digitalization contributing to economic diversification.

4.7 Tanzania

The Tanzania Digital Economy Policy (2019) promotes the development of digital skills across various sectors, including TVET (The United Republic of Tanzania, 2023). Specifically, the SmartClass was launched in Tanzania in 2019, which is an online platform that uses big data and artificial intelligence to match students to qualified and certified tutors based on their learning needs with a focus on academics, agriculture, information technology (IT), business, exams preparations, language learning, vocational education, dance, and music (Ogada, Ojenge, Galia & Odiwuor, 2024). Key success factors:

- Support from international donors to fund digital skill initiatives in TVET
- Tailoring digital training to local industries like agriculture and manufacturing enhances relevance.

Impact: Increased digital literacy among TVET students and Greater integration of AI tools in vocational training. Also, Improved employability in emerging sectors.

4.6 South Africa

South Africa's TVET system is incorporating digital skills and AI through curriculum reforms, digital labs, and partnerships with industry and international organizations (Republic of South Africa, 2020). The focus includes digital literacy, coding, AI fundamentals, and data analysis. One successful application of technology in education in

South Africa is the introduction of Daptio, founded in 2013 and based in Cape Town. It is an adaptive learning platform that utilises artificial intelligence to support students in remote learning. It specializes in courses whose content, structure, and assessments are designed to adjust based on the strengths and weaknesses of the students (Ogada, Ojenge, Galia & Odiwuor, 2024). Key success factors:

- The Digital Skills Strategy emphasizes AI and digital literacy for youth.
- TVET colleges are upgrading facilities and curricula to include digital and AI modules.
- UNESCO and other agencies, as well as local tech companies, support capacity-building and resource development to ensure relevance and effectiveness.

Impact: Increased digital literacy and foundational skills among students. Also, better alignment of graduates' skills with evolving labour market needs.

4.7 Lessons for Nigeria

Policy and Strategic Vision: Countries like Singapore and South Korea have clear national strategies emphasizing digital transformation.

Public-Private Partnerships: Germany and South Korea exemplify collaboration with industries for curriculum relevance and resource sharing.

Infrastructure Investment: Singapore and Rwanda's emphasis on digital infrastructure underscores its importance.

Curriculum Innovation: Regular updates that align with Industry 4.0 and AI developments are crucial.

Inclusion: Rwanda's focus on rural access highlights the need for inclusive digital skills development.

4.8 Nigeria

Nigeria's TVET system is increasingly recognizing the importance of digital skills and AI to address unemployment, skills gaps, and technological advancement. Key initiative in this context is the development of Nigeria's National Digital Economy Policy and Strategy (NITDA, 2020) which emphasizes digital skills development across sectors, including TVET. Key successes include;

- Institutional Reforms and Curriculum Modernization at basic, secondary and tertiary education levels, leading to upgrading curricula to include ICT and AI modules powered by agencies such as NBTE, NUC, NCCE, and NERDC.
- Public-Private Partnerships and Industry Engagement, resulting in collaboration with tech companies (both foreign and local), startups, and industry associations to ensure the relevance of training and facilitate apprenticeships, internships, and mentorship programmes (Nwachukwu & Okafor, 2022). Some leading tech companies in this partnership are Huawei, CISCO and several other indigenous companies.
- Digital Infrastructure and access to foster digital literacy through expansion of internet connectivity, provision of computer labs, and deployment of online learning platforms in instruction delivery at both secondary and tertiary education levels, being supervised by NITDA.
- Capacity Building and Training of Trainers through Professional development programs for instructors to deliver digital and AI content effectively, ensuring quality and sustainability.

Impact: Improved employability, innovation, entrepreneurship, digital inclusion, and addressing youth unemployment. In Nigeria, however, due to either a general lack of awareness or inadequate preparation for the digital transformation taking place in the country, digital transformation has yet to yield results to the extent and depth desired in the nation's economic diversification.

5 Challenges

Despite the progress in integrating digital skills and AI into Nigerian TVET, significant challenges must be addressed. Understanding these barriers is essential for developing effective strategies:

5.1 Fragmented Governance and Policy Implementation

The governance of TVET in Nigeria is characterized by fragmentation across multiple ministries, agencies, and levels of government. This fragmentation, sometimes with overlapping functions, complicates policy coherence and implementation.

5.2 Infrastructure Limitations

Nigeria faces severe infrastructure constraints that impede the integration of digital technologies in TVET. Irregular electricity supply, limited internet connectivity, and insufficient access to hardware represent fundamental barriers. These infrastructure gaps are particularly pronounced in rural and economically disadvantaged areas.

5.3 Digital Divide and Access Inequities

The digital divide in Nigeria is in multiple dimensions: urban versus rural, high-income versus low-income, and gender-based disparities in technology access and use. This divide can constitute a limitation to the integration of digital technology and AI in TVET.

5.4 Instructor Capacity and Readiness

Many TVET instructors in Nigeria lack the digital competencies required to effectively integrate technology into their teaching (Okanya, 2023). This capacity gap represents a significant barrier to modernizing TVET delivery across all sub-themes of our conference.

5.5 Curriculum Relevance and Responsiveness

Nigerian TVET curricula often evolve too slowly to keep pace with rapid technological change in the labour market (Lasisi & Owolabi, 2024; Okwelle, 2024).

5.6 Funding Constraints

TVET in Nigeria faces serious underfunding, with particular deficits in resources for technological infrastructure and digital content development. Poor funding can significantly constrain investment in the tools, systems, and professional development required for effective digital integration (Okwelle, 2024a).

5.7 Industry Engagement Limitations

here is still insufficient collaboration between Nigerian TVET institutions and industry partners in developing and implementing digitally-enhanced programs. This disconnect leads to misalignment between educational outcomes and labour market requirements.

5.8 Assessment and Certification Challenges

Traditional assessment methods in Nigerian TVET often fail to adequately measure digital competencies, which undermines the recognition and certification of the very skills we seek to develop.

6 Prospects

Despite the challenges outlined, there are promising prospects for integrating digital skills and AI into Nigeria's TVET system to promote economic diversification. These opportunities cut across pedagogical innovation, technological advancement, and institutional transformation:

6.1 Personalized and Adaptive Learning

AI technologies offer unprecedented opportunities for personalization in TVET delivery. Adaptive learning systems can analyze learner performance data to identify knowledge gaps and recommend appropriate learning resources, enabling more efficient and practical skill development (Baako, 2025). These systems are particularly valuable in vocational contexts where learners often come with diverse prior experiences and learning needs.

6.2 Simulation and Immersive Learning Environments

Virtual reality (VR), augmented reality (AR), and mixed reality technologies can create immersive learning environments that simulate workplace conditions and equipment across all TVET domains. These technologies enable learners to develop and practice skills in a safe, controlled environment before entering actual workplaces. VR allows trainees to perform hazardous or complex tasks—such as welding at heights, operating heavy machinery, or handling dangerous chemicals—without real-world risks. The immersive nature of AR and VR can capture learners' attention more effectively than static materials, while also enabling resource-scarce institutions to offer higher-quality, practical training**.**

Virtual reality (VR), augmented reality (AR), and mixed reality technologies can create immersive learning environments that simulate workplace conditions and equipment across all TVET domains. These technologies allow learners to develop and practice skills in safe, controlled settings before entering actual workplaces. VR enables trainees to perform hazardous or complex tasks—like welding at heights, operating heavy machinery, or handling dangerous chemicals—without real-world risks. The immersive nature of AR and VR can capture learners' attention more effectively than static materials and at the same time, enabling resource-scarce institutions to offer higher-quality practical training.

6.3 Mobile Learning and Micro-credentialing

Mobile technologies offer opportunities to extend TVET access beyond traditional institutional boundaries. Mobile learning applications, coupled with micro-credentialing systems, can provide flexible, modular pathways for skills development that accommodate learners' life circumstances. This approach is particularly promising for reaching Nigeria's large informal sector workforce, who may not be able to participate in conventional full-time TVET programmes.

6.4 Data-Driven Programme Design and Delivery

Analytics tools can provide TVET programmes with unprecedented insights into program effectiveness, learner progress, and skills outcomes.

6.5 AI-Enhanced Career Guidance and Job Matching

AI systems can analyze labour market data and individual competency profiles to provide personalized career guidance and job matching services. These systems can help TVET students make informed decisions about specialization pathways and connect graduates with relevant employment opportunities.

6.6 Cross-disciplinary Innovation

The integration of digital skills across TVET domains creates opportunities for cross-disciplinary innovation. For example, the combination of agricultural technology with data analytics enables precision farming; the integration of AI with mechanical technology supports predictive maintenance; and the merger of digital skills with entrepreneurship education fosters technology-enabled business models. These intersections represent fertile ground for economic diversification and value creation.

6.7 Public-Private Partnership Models

The digital transformation of TVET creates new opportunities for innovative public-private partnerships. Models such as industry-sponsored digital labs, corporate social responsibility initiatives focused on digital skills development, and co-investment in technological infrastructure can help overcome resource constraints while ensuring industry relevance.

6.8 Regional Collaboration and Resource Sharing

Digital technologies have the potential to engender new models of collaboration among TVET institutions across Nigeria and beyond. Virtual learning communities, shared digital repositories, and collaborative content development can help overcome resource limitations while fostering a community of practice around digitally-enhanced vocational education.

7 Conclusion

In conclusion, the integration of digital skills and AI into TVET represents both an imperative and an opportunity for Nigeria's economic diversification in the 21st-century education landscape. The Fourth Industrial Revolution is not waiting for our readiness; it is unfolding in real-time, transforming occupations across all the sub-themes of our conference. The comparative analysis of international practices reveals that successful integration requires a systems approach encompassing policy coherence, infrastructure development, instructor capacity building, curriculum modernization, and strong industry partnerships. While Nigeria faces significant challenges in each of these areas, there are also promising prospects for leveraging digital technologies to enhance the accessibility, quality, and relevance of TVET across all vocational domains.

The true promise of digitally enhanced TVET lies not merely in producing graduates who can operate current technologies but in developing adaptive experts who can navigate technological change throughout their careers. This requires attention not just to specific digital tools but to the development of humans with computational thinking, digital problem-solving, and lifelong learning capabilities.

As we contemplate Nigeria's path forward, the integration of digital skills and AI into TVET is not merely a technical challenge but a strategic opportunity to position Nigeria as a competitive player in the global knowledge-based digital economy. By embracing this opportunity with vision, commitment, and coordinated action, we can create a TVET system that not only responds to technological change but actively shapes it in the service of inclusive and sustainable development.

8 Recommendations

Based on the analysis presented, the following recommendations are made:

1. The government should formulate and implement a unified national strategy for integrating digital skills and AI in TVET, with clear objectives, effective governance structures, and robust accountability mechanisms.
2. Both the government and institutions of learning involved in TVET should increase investment in digital hubs, mobile learning, and renewable energy, and create community access points to bridge infrastructure gaps and ensure inclusive participation.
3. There should be a nationwide programme to upskill TVET instructors in digital pedagogy and create platforms for industry attachments and peer learning.
4. Schools running TVET programmes in collaboration with their regulatory agencies should establish structured partnerships with industry for curriculum co-design, work-based learning, joint research, and innovation.
5. Regularly update the TVET and teacher training curricula of our educational system to align with emerging global demands and technology-enhanced instructional delivery methods.
6. TVET policy makers should develop strategies to programme inclusively so that marginalized groups, including women, rural learners, and persons with disabilities, have easy access to learning. This can be achieved by using accessible technologies.
7. A monitoring mechanism should be established to track progress, forecast digital skills needs, and publish annual reports to inform policy and practice.

By implementing these recommendations through coordinated action across stakeholder groups, Nigeria can harness the transformative potential of digital skills and AI in TVET to drive economic diversification and position the country for success in the 21st-century global economy.

References

Anyaehie, M. C., & Areji, A. C. (2015). Economic diversification for sustainable development in Nigeria. *Open Journal of Political Science*, 5(2), 87-94.

Awangku, M. H. B. A. D. (2025). *Digitalization of TVET: 7 how technology drives the transformation of technical and vocational education*. Retrieved from https://blog.fame.edu.my/digitalization-of-tvet/

Baako, I. (2025). A bibliometric investigation of artificial intelligence in technical and vocational education training (AI-TVET): Trends and insights for a decade. https://doi.org/10.21203/rs.3.rs-6431518/v1

CEDEFOP (2020). Skills for the digital era: Report on digital skills development. *European Centre for the Development of Vocational Training*. https://www.cedefop.europ.eu

CEDEFOP (2025). VET 4.0 project: effects of digital innovation on vocational training. Retrieved from https://www.cedefop.europa.eu/en/tools/timeline-vet-policies-europe/search/28126

Cheng, Y. M. (2019). How does task-technology fit influence cloud-based e-learning continuance and impact? *Education + Training*, 61(4), 480-499.

Coward, C., & Fellows, M. (2018). *Digital skills toolkit*. International Telecommunication Union.

Danlami, D., Abdullahi, Y. N., Nafi'u, I., & Hafsat, M. (2025). Comparative analysis of education and unemployment rate In Nigeria (1993-2023). *Alvan Journal of Social Sciences (AJSS), 2*(1), 1-11.

Fung, M., Taal, R. & Sim. W (2021). SkillsFuture: The Roles of Public and Private Sectors in Developing a Learning Society in Singapore (p.195 – 207). In S. Ra et al. (eds.), *Powering a Learning Society During an Age of Disruption*, Education in the Asia-Pacific Region: Issues, Concerns and Prospects, Vol 58. https://doi.org/10.1007/978-981-16-0983-1_14.

Government of India (2020). National Skills Development Policy. Ministry of Skill Development & Entrepreneurship, India. http://www.msde.gov.in

Gwang H. A. (2023). The world is focusing on South Korea's smart factories. Newsroom. https://www.automationworld.co.kr

Holmes, W., Bialik, M., & Fadel, C. (2021). Artificial Intelligence in Education: Promises and Implications for Teaching and Learning. *Center for Curriculum Redesign*.

Iyanda, O., & Balogun, V. F. (2017). Learning analytics for quality assurance in Nigerian technical colleges. *International Journal of Advanced Computer Science and Applications*, 8(7), 288-295.

Lasisi, S. A., & Owolabi, S. O. (2024). Enhancing Technical Vocational Education and Training (TVET) for Sustainable National Security and National Development in Nigeria. *Kashere Journal of Education*, *6*(1), 251-258.

Morley, S. (2024). *Empowering vocational education through artificial intelligence: a practical guide for hands-on educators*. Retrieved from https://www.worldoftvet.com/blog/empowering-vocational-education-through-artificial-intelligence

Mahmood, A., Ali, H., & Bilal, A. (2018). The mediating role of career competencies between institutional learning environment and career success: a process model for producing tvet skilled workforce. *Journal of Quality & Technology Management*, *15*(1), 57-85.

National Bureau of Statistics (2023). Nigerian gross domestic product report Q3 2023. Retrieved from https://www.nigerianstat.gov.ng/pdfuploads/Q3_2023_GDP_Report.pdf

National Bureau of Statistics (2024) Nigeria Youth Unemployment Rate. https://tradingeconomics.com/Nigeria/youth-unemployment-rate

National Information Technology Development Agency (2020). Nigeria's Digital Economy Policy and Strategy. Abuja

Ogada, T., Ojenge, W., Galia, M., & Odiwuor, A. (2024). *Application of artificial intelligence in education in Africa*. Acts Artificial Intelligence Publication Series

Okanya, V. (2023). Enhancing integration of emerging technologies in technical vocational education and training (TVET) programmes for sustainable development. *Industrial Technology Education Research Journal*, *6*(1), 73-85.

Okoye, K. R. E., & Okwelle, P. C. (2014). Technical Vocational Education and Training (TVET) as intervention mechanism for global competitiveness: Perspectives from Nigeria. *Developing Country Studies*, 4(4), 85-91.

Okwelle, P. C. (2024). Enhancing curriculum delivery for improvement of education in Nigeria. *Journal of Curriculum and Instruction*, 14(1),1 – 9.

Okwelle, P. C. (2024a). Artificial Intelligence and Education in 21st Century: Issues, Challenges, and Prospects. Keynote Address Presented at the Education Foundations International Conference held at the Faculty of Education Auditorium, University of Port Harcourt, Nigeria on 13th November, 2024.

Olabiyi, O. S., & Chinedu, C. C. (2025). The Convergence of Technology and Vocational Pedagogy and Artificial Intelligence for Driving Transformation and Creating a Sustainable Workforce. In *Rethinking the Pedagogy of Sustainable Development in the AI Era* (pp. 277-306). IGI Global Scientific Publishing.

Republic of South Africa (2020). National Digital and Future Skills Strategy South Africa. Department Of Communications and Digital Technologies. https://www.gpwonline.co.za

Russell, S., & Norvig, P. (2016). *Artificial Intelligence:* A Modern Approach. Pearson Education Limited, Malaysia.

Rwanda Development Board. (2021). *Digital Rwanda: A Path to Economic Growth*. RDB Publications. https/rdb.rw/Rwanda-development-board-annual-rep.

Singapore Ministry of Education (2022). Skillsfutrue for you. http://www.skillfuture.gov.sg

The Korea Herald (2025, June25). South Korea considers making AI standalone subject in schools. https://koreaherald.com/article/105175448.

The United Republic of Tanzania, 2023. National ICT policy. Ministry of Information, Communication and Information Technology. https://www.mawasiliano.go.tz

UNESCO-UNEVOC. (2021). Enhancing TVET for Sustainable Development. https://unescodoc.unesco.org.

World Bank (2021). *Digital Skills: A Foundation for the Future of Work in Africa*. Washington, D.C.: World Bank Group.

World Economic Forum (2016). The future of jobs employment, skills and workforce strategy for the fourth industrial revolution. https://www3.weforum.org/docs/WEF_FOJ_Executive_Summary_Jobs.pdf

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education*, 16(1), 1-27.

Bridging a Skill Gap of Technical and Vocational Education and Training (TVET) Teachers in Digital Skills for Lifelong Learning

Professor T. M. SABA
Professor of Industrial and Technology Education
Federal University of Technology Minna, Nigeria
mosessaba@futminna.edu.ng; +2348036324657

LEAD PAPER PRESENTER I

BEING A LEAD PAPER PRESENTED AT THE 38TH ANNUAL NATIONAL CONFERENCE OF TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (TEPAN) HELD AT DR. GAMBO HAMZA HALL, PERMANENT SITE, FCT COE, ZUBA, ABUJA (ON 7TH JULY, 2025)

Protocols

Abstract

The study focused on Technical and Vocational Education and Training (TVET) Teachers, to bridge the skill gap in digital skills for lifelong learning. Digital technologies have become increasingly central to life, creating the need to teach students essential digital literacy skills to thrive both academically and professionally. While lifelong learning is a chance for people to keep learning throughout their life. The study examined some essential digital skills, benefits of using digital skills in teaching and learning, benefits of lifelong learning, relationship between digital skill and lifelong learning, Techniques of bridging the gap of TVET Teachers in digital skills, challenges of acquiring digital skills by TVET Teachers. Learning a digital skill is a transformative journey that offers innumerable benefits in today's technology-driven world. It is recommended among others that; Government and educational institutions should provide ongoing ICT and EdTech training workshops**,** tailored specifically to technical subjects. Upgrade schools with reliable internet access**,** computers**,** smartboards**,** and solar backup systems to create a digital-friendly teaching environment. Revise teacher training curricula (in colleges of education and universities) to include mandatory digital competency modules**.**

Key words: Bridging Gap, TVET Teachers, Digital Skills, Lifelong Learning

Introduction

Technical and vocational educators are trained individuals who provide instruction or education in teaching technical or vocational subjects. Technical and vocational teachers are teachers who recognizes the value of technology in the classroom, possesses the knowledge to teach students about the use of technology and digital resources, and has the ability and desire to use technology (Saba, *et al.*, 2016). The readiness of technical and vocational educators to adopt the digital learning approach depends on the level of digital literacy acquired by the educators. Many teachers in schools are unfamiliar and are not taught to use computers and the internet, as such, they found it challenging to embrace the use of technologies in teaching and learning processes in schools (Muhammad, *et al*, 2024; Olanrewaju *et al* 2022). With this situation, it won't be easy to implement digital technology effectively in technical colleges. A study conducted by Mahmud *et al*, (2024) also revealed 17 digital learning skills that TVET educators required to implement digital learning in technical colleges effectively, 12 digital skills have not been acquired by TVET educators which are necessary to implement digital learning in technical colleges. They furthered recommended that Government should give TVET educators in technical colleges the opportunity to acquire new or improved skills needed for the adoption of digital technology in teaching through re-skilling and up-skilling.

Digital skills can be seen as the ability to find, evaluate, use, share, and create content using digital devices, such as computers and smartphones**.** As the digital and workforce landscape evolves, it's necessary to continuously learn new digital skills to remain competitive. Even if

industries where it may seem digital skills are not really needed, applicants will need enough digital proficiency to organize a resume, navigate online job boards, complete a digital application and participate in remote interviews. Digital technologies have become increasingly central to life, creating the need to teach students essential digital literacy skills to thrive both academically and professionally (Serezhkina, 2021). Digital literacy involves using technology to learn, create, and participate in the digital world. Essential skills connected to digital literacy include collaboration, communication, critical thinking, and creativity. These skills are crucial for students to navigate and leverage technology effectively in both classroom settings and their everyday lives. Understanding digital skills is crucial for educators to integrate technology into their teaching practices effectively. The role of digital skills in education is to prepare students for the digital world and equip them with the skills necessary to navigate it (Tomczyk, 2021). Digital skills development should be integrated into the curriculum at all levels of education, from primary school to higher education. By doing so, students can develop the skills they need to succeed in the digital age and become more competitive in the workforce (Utebor, *et al,* 2024). Teachers are using learning management systems, training providers are using virtual reality to simulate authentic work environments, and parents need to understand digital communication systems in use at their children's schools. Digital skills competences are great resources require for lifelong learning in TVET.

Lifelong learning refers to the concept that there is always something new to be learned—regardless of whether it's for personal fulfillment or professional development and career advancement. The idea behind lifelong learning is that, even once your days of formal education are complete, it's worthwhile to pursue more knowledge and skills with each passing year (Ebru, 2024). In other words, lifelong learners never consider their education truly complete. Lifelong learners are not complacent; they're always seeking new ways to explore novel concepts, pursue new hobbies, and improve themselves. Lifelong learning is a chance for people to keep learning throughout their life. It's a continuous effort, and it has been defined as "a lifelong process of enhancing skills, wisdom, and abilities, which facilitate the acquisition of new knowledge and development of competencies to meet personal goals, challenges, and opportunities (Ebru, 2024). Lifelong learning is a self-directed process of learning that continues throughout life. It encompasses an individual's desire to acquire new skills and knowledge to improve efficiency. It includes autodidactic, the study of one's self through experience, and other forms of individualized learning such as mentorship, apprenticeship, and experiential education.

Digital skills

Digital skill, which is also known as "Tech Skills" has become an integral part of our daily lives, transforming the way we work, communicate, and access information. As the digital landscape continues to expand, the demand for individuals with digital skills has never been higher. Whether you are a teacher, lecturer, student, a professional looking to advance your career, or simply curious about the digital realm, learning a digital skill offers a plethora of benefits that can enrich your life and open new opportunities. Digital skills are becoming increasingly important in education, as technology continues to play a more significant role in our daily lives (Utebor, *et al,* 2024). Digital skills are the abilities to use digital technologies, communication tools, and networks to access, manage, integrate, evaluate, and create information in order to function in a knowledge-based society. In education, digital skills are essential for both teachers and students to succeed in today's digital age (Onyebuenyi and Oluka, 2022). Teachers should possess a range of digital skills to effectively integrate technology into their teaching. Below are some essential categories:

1. **Basic Digital Literacy:** The foundation of digital skills includes:
   i. Using digital devices such as computers, smartphones, and tablets.

ii. Navigating the internet effectively.
iii. Managing online accounts securely.

2. **Data Management:** Data management involves:
i. Collecting and storing data efficiently.
ii. Organizing and analyzing information.
iii. Understanding database management for business, research, and administration.

3. Software Proficiency: Mastering digital tools and software applications enhances work efficiency.

Key software skills include:
i. Word processors (Microsoft Word, Google Docs).
ii. Spreadsheets (Excel, Google Sheets).
iii. Design tools (Adobe Photoshop, Canva).
iv. Project management tools (Trello, Asana, Monday.com).

4. Cybersecurity Awareness

One of the most critical digital skills is cybersecurity awareness, which helps prevent fraud and cyber threats. This skill includes:
i. Using secure passwords and encryption.
ii. Recognizing phishing scams.
iii. Protecting personal data from cybercriminals.
iv. Implementing secure identity verification.

5. Social Media Management

This skill involves:
i. Creating engaging content for digital platforms.
ii. Managing business or personal accounts strategically.
iii. Interacting with online audiences effectively.

6. Digital Marketing

This skill involves leveraging digital platforms for marketing purposes.
Key digital marketing areas include:
i. Search Engine Optimization (SEO).
ii. Social media marketing.
iii. Email marketing and automated campaigns.
iv. Performance-based advertising (SEM, Google Ads, Facebook Ads).

7. Content Creation: Content creation is a highly sought-after digital skill.
It includes writing blog posts and articles, producing videos and podcasts, designing infographics and digital visuals.

8. Data Analysis

Data analysts play a critical role in:
i. Gathering and processing data from multiple sources.
ii. Identifying patterns and business trends
iii. Making data-driven decisions for companies.

Benefits of Using Digital Skills in Teaching and Learning

Enhanced Teaching Practices: Digital tools and resources allow teachers to create engaging lessons, incorporate multimedia elements, and utilize interactive platforms, making learning more dynamic and stimulating.

Personalized Learning: Digital platforms enable teachers to tailor instruction to individual student needs, provide personalized feedback, and adapt lessons based on student progress.

Effective Communication: Digital tools facilitate communication with students, parents, and colleagues, enabling teachers to stay connected, share resources, and collaborate on projects.

Increased Efficiency: Digital tools can streamline administrative tasks, automate grading,

and facilitate online assessments, freeing up teachers' time for more meaningful interactions with students.

Professional Development: Digital skills empower teachers to access online resources for professional development, participate in virtual conferences, and stay abreast of the latest trends in education.

Benefits of Lifelong Learning

1. Keeps Skills Up to Date: Lifelong learning helps technical teachers stay current with emerging technologies, tools, and teaching methods in their field.

2. Improves Teaching Quality: Continued learning enables teachers to refine instructional strategies, making lessons more effective, engaging, and relevant.

3. Boosts Career Growth: By acquiring new qualifications and skills, technical teachers can qualify for promotions, leadership roles, or specialist positions.
4. Enhances Adaptability: Lifelong learners are better prepared to adapt to changes in education policy, curriculum updates, and evolving industry standards.
5. Promotes Innovation in the Classroom: Ongoing learning fosters creativity and innovation, encouraging teachers to adopt new technologies, tools, and project-based learning techniques.
6. Strengthens Professional Confidence: As teachers gain knowledge and experience, they develop greater confidence in their abilities and decision-making.
7. Encourages Role Modeling: When teachers engage in lifelong learning, they set a positive example for students, promoting a culture of continuous self-improvement.
8. Facilitates Better Student Outcomes: Well-informed and updated teachers are better equipped to guide students effectively, especially in practical and technical subjects.
9. Increases Job Satisfaction: Lifelong learning can lead to personal fulfillment and reduced burnout, as teachers feel more competent and motivated.
10. Opens Opportunities for Collaboration: Continuous learning connects teachers with professional networks, conferences, and research initiatives, encouraging knowledge exchange and teamwork.

Relationship Between Digital Skill and Lifelong Learning

Digital skills and lifelong learning are intertwined, as digital competence is crucial for accessing and utilizing the vast resources available for continuous learning. Lifelong learners need digital skills to find information, evaluate its accuracy, and participate in online learning communities (Sulak. *et al,* 2022). Conversely, digital skills themselves are best developed through a lifelong learning approach, allowing individuals to adapt to the ever-changing technological landscape.

1. **Access to Information**: Digital skills enable individuals to find, evaluate, and use vast online resources for self-directed learning, enhancing continuous education.
2. **Flexible Learning Opportunities**: Lifelong learning increasingly occurs on digital platforms (Massive Open Online Courses (MOOCs,) webinars). Digital literacy is essential to participate effectively.
3. **Improved Problem-Solving**: Digital tools support experimentation and innovation, helping lifelong learners tackle real-world challenges using technology-enhanced solutions.
4. **Enhanced Communication**: Digital skills facilitate collaboration through email, social media, forums, and video conferencing, essential for networking and peer learning.
5. **Career Development**: Lifelong learners need digital competencies to upskill/reskill, stay relevant in the job market, and adapt to technological advancements in their

fields.

6. **Personalized Learning**: With digital skills, learners can tailor educational content and pace to meet their individual needs using adaptive learning technologies.
7. **Digital Citizenship**: Lifelong learners must understand online ethics, privacy, and security to navigate digital environments safely and responsibly.
8. **Critical Thinking and Evaluation**: Being digitally skilled helps individuals assess the credibility of information sources—an essential part of effective lifelong learning.
9. **Motivation and Engagement**: Interactive digital tools (games, simulations, multimedia) can increase engagement and motivation in lifelong learning processes.
10. **Bridging the Digital Divide**: Promoting digital skills reduces educational inequalities and empowers all individuals to participate fully in lifelong learning opportunities.

Techniques of Bridging the Gap of TVET Teachers in Digital Skills

1. **Professional Development Workshops**: Organize hands-on training sessions on digital tools, educational technology, and online teaching platforms relevant to technical subjects.
2. **Online Courses and Certifications**: Encourage teachers to enroll in MOOCs (e.g., Coursera, edX, LinkedIn Learning) focused on ICT integration, coding, and digital pedagogy.
3. **Peer Mentoring and Collaboration**: Pair less digitally skilled teachers with tech-savvy colleagues for support, co-teaching, and shared learning experiences.
4. **Regular ICT Competency Assessments**: Assess teachers' digital proficiency and identify skill gaps to guide targeted training and support.
5. **Incorporate EdTech into Lesson Planning**: Train teachers to use educational software (Simulations, Computer Aided Design (CAD) tools, Learning Management System (LMS) platforms) directly in curriculum delivery.
6. **Establish Digital Learning Communities**: Create forums or groups where teachers can share resources, experiences, and strategies for using digital tools effectively.
7. **Provide Access to Digital Tools and Infrastructure**: Ensure teachers have up-to-date hardware, software, internet access, and technical support to practice and implement digital teaching methods.
8. **Encourage Participation in Webinars and Virtual Conferences**: These platforms expose teachers to global best practices and emerging technologies in technical education.
9. **Gamified and Interactive Learning Platforms**: Introduce teachers to engaging digital environments (eKahoot!, Quizizz, coding sandboxes) to enhance their familiarity and student engagement.
10. **Set Institutional Digital Competency Goals**: Integrate digital skill development into teacher performance appraisals and school improvement plans to foster accountability and growth.

Challenges of Acquiring Digital Skills by TVET Teachers

1. Inadequate Infrastructure: Limited access to reliable electricity, internet connectivity, and modern digital devices hampers digital skill acquisition.
2. **Lack of Professional Training Opportunities:** Few targeted workshops or formal training programs are available to help technical teachers develop relevant ICT and EdTech competencies.
3. **High Cost of Digital Tools:** Digital tools, software licenses, and internet data are often unaffordable for many teachers, especially in rural areas.
4. **Poor Government and Institutional Support:** Limited policy implementation and

funding from government or school management reduce the chances of structured digital skill development.

5. **Low Digital Literacy Levels:** Many technical teachers have limited foundational ICT knowledge, making it harder to adapt to newer educational technologies.
6. **Resistance to Change:** Some teachers are reluctant to shift from traditional teaching methods to digital approaches due to fear, skepticism, or lack of motivation.
7. **Overloaded Curriculum and Time Constraints:** Heavy teaching workloads leave little time for teachers to engage in training or self-paced digital learning.
8. **Limited Access to Technical Support:** Lack of on-site IT support makes it difficult for teachers to resolve tech issues or confidently use digital tools.
9. **Language and Content Relevance Barriers:** Many online training resources are not tailored to the Nigerian context or technical education curriculum, reducing their usefulness.

Conclusion

Learning a digital skill is a transformative journey that offers innumerable benefits in today's technology-driven world. Begins from career development, advancement, creativity and adaptability digital skills enrich every aspect of life. There is a great need to embrace the digital age, we must invest in your career growth, and utilized endless opportunities that come with mastering a digital skill. The time TVET teachers are to explore digital skill is now. In other words, digital skills are now a must, not an option. Digital skills provide numerous benefits as a TVET teachers, it helps in prepare, deliver, and assess lessons more efficiently using tools like PowerPoint, simulations, and e-assessment platforms. With digital tools such as videos, animations, and interactive software, technical teachers can make abstract or complex concepts easier to understand and more engaging.

Recommendations

1. Organize Regular Digital Literacy Training: Government and educational institutions should provide ongoing ICT and EdTech training workshops, tailored specifically to technical subjects.
2. Improve ICT Infrastructure in Schools: Upgrade schools with reliable internet access**,** computers**,** smartboards**,** and solar backup systems to create a digital-friendly teaching environment.
3. Integrate Digital Skills into Teacher Education: Revise teacher training curricula (in colleges of education and universities) to include mandatory digital competency modules**.**
4. Provide Subsidized or Free Access to Devices: Offer low-cost laptops, tablets, and data plans for teachers, especially in rural and underserved areas.
5. Incentivize Digital Skill Acquisition: Introduce rewards, recognition, or career advancement opportunities for teachers who complete digital training programmes.
6. Develop Locally Relevant e-Learning Content: Create Nigerian-context-based online learning materials and tutorials that align with the technical curriculum.
7. Foster Peer Mentoring and Digital Learning Communities: Encourage experienced digital users to mentor colleagues**,** and build online teacher support networks for sharing tools, tips, and solutions.
8. Establish Public-Private Partnerships: Collaborate with tech companies (Microsoft, Google, local startups) to deliver capacity-building programmes and donate equipment.

References

Ebru E. (2024) The relationship between digital literacy levels and lifelong learning tendencies of future teachers. *South African Journal of Education, 44 (4)* https://doi.org/10.15700/saje.v44n4a2537

Mahmud, M. J. Mohd S. B. N., Ahmed, J. W. & Adedayo, T. Q. (2024) Skills gap assessment among Technical and Vocational Education and Training Educators (TVET) on adopting digital technologies in teaching at Technical Colleges. *International Journal of Academic Research in Progressive Education and Development* 13, (3) 1489 - 1502

Muhammad A. A., Muhammad, K. N., Ahmad-Nabil B. M.N, Muhammad Haznil-Hafiq B. H. H (2024) Assessing the Importance of Digital Literacy as a 21st Century Skill among TVET Educators. *International Journal of Academic Research in Progressive Education and Development* 13 (4) 434- 450

Oladipupo B. & Abdulazeez O. A. (2024) Digital Literacy and Skills Development in Nigeria: Policies, Barriers and Recommendations. *Journal of African Innovation & Advanced Studies (JALAS)* 5 (2) 133-150

Olanrewaju, B. U., & Afolabi, J. A. (2022). Digitising education in Nigeria: Lessons from COVID-19. *International Journal of Technology Enhanced Learning*, *14*(4), 402–419

Onyebuenyi, P. N. & Oluka S. N. (2022). Digital competencies needed by Teachers for utilizing mobile learning applications for effective lesson delivery in Technical Colleges in Aba Education Zone of Abia State. *J Adv Educ Philos, 6*(8): 427- 436

Tomczyk, Ł. (2021) Declared and Real Level of Digital Skills of Future Teaching Staff. Educ. Sci. 2021, 11, 619. https://doi.org/10.3390/ educsci11100619

Saba, T. M., Chado, M. I. D., Abutu, F. & Mahmud, M. J. (2016). Skills and preparation improvement need of pre-service technology education teachers in the use of Information and Communication Technology (ICT) in the 21st Century. *International Journal of Research in Science, Technology and Mathematic Education University of Jos 4 (2) 225-234*

Serezhkina, A. (2021) digital Skills of teachers E3S Web of Conferences **258**, 07083 https://doi.org/10.1051/e3sconf/202125807083

Sulak, S. E., Çetinkaya, S. & Çapanoğlu, A. S. (2022) Examination of the relationship between digital literacy and lifelong learning tendencies of primary school teachers. *Journal of Learning and Teaching in Digital Age,* 7(2), 235-249

Utebor, J. N., Nwosu, B. O. & Azih, N. (2024) digital skills required of office technology and management education graduates for global relevance in Delta State. *International Journal of Innovative Information Systems & Technology Research 12(1):83-94,*

UTILIZATION OF DIGITAL SKILLS AND AI ON TVET FOR ECONOMIC DIVERSIFICATION IN THE 21ST CENTURY EDUCATIONAL LANDSCAPE

Professor Joy Obiageli Nwokolo-Ojo
Head of Department Vocational and Technical Education
Benue State University, Makurdi
obiagelinwokolo5@gmail.com; +2347031284813

LEAD PAPER PRESENTER II

BEING A LEAD PAPER PRESENTED AT THE 38TH ANNUAL NATIONAL CONFERENCE OF TECHNOLOGY EDUCATION PRACTITIONERS ASSOCIATION OF NIGERIA (TEPAN) HELD AT DR. GAMBO HAMZA HALL, PERMANENT SITE, FCT COE, ZUBA, ABUJA (ON 7TH JULY, 2025)

Protocols

Preamble:

I sincerely thank the organizers of this Technology Education Practitioners Association of Nigeria (TEPAN) for appointing me to present the lead paper. I therefore, seize this opportunity to welcome all participants to this conference.

The digital revolution is rapidly transforming the world of work and the skills profiles of many occupations. The pace of change necessitates continuous skilling and re-skilling through digital skills and Artificial Intelligence (AI). Traditional skill-based model of Technical, Vocational Education and Training (TVET) need urgent updating to effectively address the evolving needs of the global economy.

This article explores the crucial role of digital skills and AI within TVET to foster economic diversification, ensuring a skilled, adaptable workforce ready for the challenges and opportunities of the modern era.

The task as a lead paper speaker is to highlight and harmonize the sub-themes and the actual and potential roles of TVET, Digital skills and AI within these models, and is highlighted, together with recommendations for policy and practice.

HIGHLIGHTS OF THE PAPER:

1. The place of TVET in driving economic growth and diversification in the 21th Century.
2. The role of digital skills and AI in enhancing TVET, including personalized learning, adaptive assessment, and intelligent tutoring systems.
3. The importance of digital skills in TVET for modern workforce.
4. Overview of AI Tools in TVET.
5. Benefits for innovation and reform of Digital skills and AI in TVET.
6. Strategies for effective integration of digital skills and AI in TVET programmes.
7. Challenges facing TVET, including inadequate infrastructure, outdated curriculum, and limited access to technology
8. Conclusion:
9. Recommendations for policy makers, educators and industry stakeholders.

INTRODUCTION:

The 21th century educational landscape is characterized by rapid technological advancement particularly in the realms of TVET, demanding a significant shift in how we approach technical, vocational education and training. This article explores the fundamental roles of digital skills and artificial intelligence (AI) within TVET to foster economic diversification, ensuring a skilled, adaptable workforce ready for the challenges and opportunities of the modern era.

Rapid advancements in TVET are largely responsible for this shifting landscape. Asha (2019) described the dynamics of the technological revolution, claiming that change is not only non-linear and unpredictable but also inevitable. Technology is being integrated into all professions and industries and is transforming traditional occupational profiles.

"The theme of this conference is the Utilization of digital skills and AI in TVET for economic diversification in the 21st Century educational landscape". Digital skills and AI competencies in TVET refer to new competencies need by individuals for the maintenance and repair of modern machineries .These advancements present both challenges, opportunities, especially for TVET systems aiming to contribute to economic diversification.

For academic conferences addressing these critical issues, the lead paper presentation plays a pivotal role in setting the tone and framing the discussion.

Through inclusive youth equitable and equality education in TVET, we are sure of promoting life-long learning opportunities for all in 21st century. The major goal of every nation is to ensure sustainable social, environmental, and economic development that empowers the citizens for good quality life. According to Nwokolo-Ojo (2024), children of today require skills to unlock their potential for innovation, employability and responsible citizenship.

Realizing these objectives depends on the investments we make today, towards the development of our children. The information accessed through digital technologies can promote innovation, increase productivity and enrich the quality of life. TVET has become very relevant to Nigeria of today, where massive unemployment of both youths and adults is on the increase.

For instance, how digital skills beliefs can be promoted through training? Nwokolo (2012) stresses the need for TVET to respond to these challenges, which includes preparing students to become active and intentional learners for their initial preparation, and ongoing development across their working life.

Traditional models TVET, which view formal training as terminal, will not prepare workers well enough for the constantly evolving world of work in an age of technological and economic diversification, focusing on gaps in the research and areas needing further exploration. Therefore, there is need to prepare for this economic transformation\diversification process. The digital revolution is rapidly transforming the world of work and the skills profiles of many occupations. Youths must develop skills that will make them to self-reliant. With TVET vocational and technological skills, youth can engage in self-employment, reducing the rate of unemployment, which always make nations unstable economically. The role of armed robbery being experienced today is evident, and youths are the active and flexible individuals in the society for such acts.

THE PLACE OF TVET IN DRIVING ECONOMIC GLOWTH AND DIVERSFICATION IN THE 21th CENTURY

In today's rapidly evolving landscape, nations are constantly seeking avenues to boost economic growth and diversify their economies, while traditional academic pathways remain important; the crucial role of TVET is becoming increasingly undeniable. TVET often overlooked in favour of university degrees, is proving to be a powerful engine driving economic prosperity and enabling nations to thrive in a competitive world.

Bridging the skills gap and fueling economic growth, the fundamental appeal of TVET lies in its direct focus on equipping individuals with the practical skills demanded by the modern workforce. Unlike purely theoretical education, TVET programmes emphasized hands-on learning, industry-specific training, and the development of competencies directly applicable to real-world jobs. This targeted approach directly addresses the skills gap, a significant obstacle to economic growth in many countries. By providing training in areas like

Manufacturing, Construction, Agriculture, Healthcare Technology and Digital trades, TVET institutions equip individuals with the qualifications needed to fill critical roles in key industries. As a result, TVET graduates are often immediately employable, contributing to increased productivity, higher wages, and a stronger overall economy. TVET is more than just job training ; It's a comprehensive approach to education that equips individuals with the skills, knowledge, and attitudes necessary for productive employment, Entrepreneurship, and lifelong learning, ultimately driving economic diversification and sustainable development. TVET can also play a broader role in raising awareness about sustainability issues and promoting sustainable lifestyles. The evidence clearly demonstrates that TVET is a powerful tool for driving economic diversification and sustainable development. By providing the skills needed to support emerging industries, promote entrepreneurship, foster innovation and adopt sustainable practices, TVET can contribute significantly to building more prosperous, resilient, and environmentally conscious economies. Realizing full potential of TVET requires a concerted effort from governments, businesses, and educational institutions. This include inversting in high – quality TVET programmes, ensuring that these programmes are aligned with the needs of the labour market, and promoting greater collaboration between educators and employers. These programmes are designed to prepare students for careers in a wide range of fields, including manufacturing, construction engineering and healthcare, hospitality and information technology. TVET programmes are often seen as an important means of providing individuals with the skills and knowledge they need to enter the workforce and succeed in their chosen careers.

DIVERSFICATION: Beyond Traditional Industries: Beyond simply filling existing jobs, TVET also plays a vital role in economic diversification. By providing training in emerging fields and innovative technologies, TVET institutions can foster entrepreneurship and support the growth of new industries. This can lead to:

1. Empowering innovation: individual with skills to develop and implement new technologies, driving innovation and creating new markets. For instance, training in renewable energy technologies can foster the growth of the green economy.
2. Supporting SMS: Small and Medium-sized Enterprises (SMS) are often the backbone of diversified economy. TVET can provide entrepreneurs with the technological and business skills needed to start and grow successful business, fostering job creation and economic activity.
3. Resilience to economic shocks: A diversified economy is more resilient to external shocks. TVET can help countries develop a skilled workforce across a range of sectors, reducing the risk of over-reliance on a single industry.
4. Investing in TVET: A strategic Imperative: Recognizing the immense potential of TVET, government and private sector stakeholders are increasingly investing in its development. Which include:
5. Modernizing Curricula: TVET curricula must be constantly updated to reflect the evolving demands of the labour market. This requires close collaboration between educational institutions and industry partners.
6. Strengthening: Infrastructure: Investing in state-of-the-art training equipment and facilities is crucial for providing high –quality TVET programmes.
7. Promoting Industry Partnerships: Collaborations between TVET institutions and businesses are essential for providing students with real-world experience through internships, apprenticeships, and mentorship programmes.
8. Changing Perceptions: Overcoming the stigma associated with vocational careers is essential for attracting talented individuals to TVET, promoting the value and earning potential of skilled trades is crucial for raising the profile of TVET.

9. The term TVET is a merger of both technical educations with the aim of training students in basic and scientific knowledge with the skills based vocational programmes. The essential role of TVET in facilitating skills development for the socio-economic and technological development of countries globally account for the increasing importance. TVET provides individuals with skills, knowledge and attitudes for effective employment in specific occupation. According to the National Policy on Education (FRN 2014) The objectives of TVET are to:
   -Provide technical manpower in applied science, technology and commerce particularly at sub professional level;
   -Provide technical knowledge and vocational skills necessary for agricultural, industrial, commercial and economic development.
   -Provide people who can apply scientific knowledge to the improvement and solution of environmental problems for the use and convenience of man.
   -Give training and impart the necessary skills leading to the production of craftsmen, technicians, and other skilled personnel who will be enterprising and self-reliant.
   -Introduce professional studies in engineering and other technologies.
   Enable our young men and women to have an intelligent understanding of the increasing complexity of technology.

TVET contribute so much in courses ranging from Electrical/Electronic technology, mechanical/automobile technology, wood technology, building technology, etc and as it was thereby demanding special attention. Unfortunately, despite all the glaring contributions of TVET, Nigeria is yet to accord this type of education the attention it deserves. It achieves these goals by offering the subjects, theoretical knowledge and practical skills that adequately respond to the requirements of an occupation. It provides a clear and defined pathway to empowerment and upward career mobility.

THE TRANSFORMATIVE POWER OF DIGITAL SKILLS AND AI IN TVET:

As industries rapidly evolve under the influence of digitization and Artificial Intelligence (AI), the skills required to thrive in the workforce are fundamentally changing. TVET institutions must adapt to equip learners with the tools and knowledge necessary to navigate this new landscape. Digital skills and AI are no longer optional add-one but integral components of a robust and relevant TVET curriculum.

1. The role of digital skills in enhancing TVET are multifaceted. Firstly, it empowers lecturers to access and utilize information more effectively. According to UNESCO (2021), Digital literacy, encompassing the ability to find, evaluate, utilize, share and create content using information technologies and the internet is becoming as essential skills for all learners in TVET. This includes proficiency in using digital plat-forms for communication, collaboration and problem-solving-skills crucial for modern workplaces.

2. Digital skills facilitate the delivery of more engaging and personalized learning experiences. Online learning platforms, interactive simulation, and virtual reality applications after innovative ways to teach complex concepts and provide practical training in a safe and controlled environment. As stated by Zawacki-Richer et. al. (2019), digital technologies can enhance flexibility, accessibility, and affordability in TVET, allowing learners to access education and training from remote locations and at their own pace. This is particularly important for reaching underserved populations and addressing skill gaps in specific regions.

3. Digital skills are essential for industries themselves. They are needed for operating sophisticated machinery, managing data, using collaborative software, and managing in remote technical support, all of which are now becoming more prevalent in various sectors.

Training individuals in digital competency needed for tasks make them more employable and more ready to add valuable skills to any workforce.

THE ROLE OF AI IN ENHANCING TVET, INCLUDE PERSONALIZED LEARNING, ADAPTIVE ASSESSMENT, AND INTELLIGENT TUTORING SYSTEMS:

Digital Skills: The Foundation for Future Success:

Beyond digital skills, AI has the potential to transform TVET in several ways:

One key application is personalized learning. AI- powered platforms can analyze learner performance, identify knowledge gaps and tailor learning pathways to individual needs. Holmes et al (2019) argue," AI can provide adaptive learning experiences that cater to different learning styles and paces, leading to improved learning outcomes" AI is automated assessment and feedback, identify areas where learners need additional support. This frees up instructor's time, allowing them to focus on more complex tasks such as mentoring and coaching. According to Hussain et. al. (2021), AI-enabled assessment systems can provide timely and objective feedback, helping learners to identify their strengths and weaknesses and improve their performance. AI can be used to stimulate real-world scenarios, providing learners with hands-on experience on a safe and controlled environment. For instance, AI-powered simulators can be used to train mechanics, electricians, and welders in troubleshooting complex problem, without the risk of damaging equipment or injuring themselves. "These digital natives" can intimidate teachers, especially teachers with little technological experience. Teachers who are less fluent with technology maintain a feeling of control in the classroom and will not have to prepare to face the challenges of instructing digital natives in a digital environment. Although technologies can be powerful means to improve learning, the teacher remains the critical factors to student's success, and must be informed of student progress in order to intervene directly with his/her students.

Teacher resistance to technology in the classroom: When adopting new classroom technologies, educators face the problem online as "double innovation' problem (Cleaver, 2014). Double innovation essentially adds an additional layer of preparation of teachers must work through. The teacher must first learn the technology well enough to utilize it in a classroom setting before deciding how to integrate the technology with classroom objectives and curriculum.

For learners, AI provides personalized feedback. Adaptive learning platforms and virtual training simulations enabling them to practice skills in a risk-free environment. This collaboration between educators and AI ensures that teaching remains deeply human while being supported by innovative technology.

Technology integration in the classroom will require the ongoing collaboration efforts of teachers, educational technology professionals, school administrators, researchers, and educational software personnel. Fortunately, the benefits to schools teachers and students will yield tremendous returns.

IMPORTANCE OF AI IN TVET

AI can automatically grade assignments, provide immediate feedback on performance, and identify areas for improvement, freeing up instructors time for more focused guidance.

1. Improved learner engagement: Personalized learning experiences can increase student's motivation and engagement.
2. Increased Efficiency: AI can automate repetitive task like grading, allowing instructors to focus on more valuable activities like mentoring and individual support.
3. Enhanced skill Development: By providing tailored feedback and targeted practice. AI can help learners develop specific skills more effectively.
4. Accessibility: AI-powered learning tools can provide flexible access to training for diverse learners including those with disabilities.

5. Overall, AI has the potential for transform TVET by providing more personalized, engaging, and effective training experiences, and better preparing learners for the evolving job market.
6. AI is also used to evaluate students. In education AI has been used to improve administration and to augment teaching and learning. It can enhance the learning experience, improve skills development, and prepare students for the demand of the job.
7. Provide adaptive learning: Learners are able to design. Plays a role in teachers' professional development. Inclusion of tomorrow's workforce in today's preparation.
8. AI has the potential for the adaptability of educational material and the vastness of TVET programmes to match today's demands and the future demands of the jobs market. AI makes TVET a continuously changing educational landscape, which is not only adjustable but exclusively centered on the person. Making vocational schooling and training more effective and responsive to labour market demands. AI can help client identify jobs in the future and skills they will require. AI –powered learning platforms within TVET institutions can effectively enhance skill acquirement and drive economic diversification.
9. AI: A Transformative Force in TVET: Artificial Intelligence is a powerful technology with the potential to revolutionalize the entire spectrum of TVET. AI-powered tools can personalize the learning experience, access student progress in real-time, and provide tailored feedback. AI systems can also automate administrative tasks, freeing educators

THE NEED FOR TRANSFORMATION OF TVET THROUGH AI:

The shift towards a digital-driven global economy necessitates a fundamental change in skills demands. Manual and repetitive jobs are increasingly being automated, while roles requiring complex problem-solving, critical thinking and adaptability are on the rise. As Schleicher(2020), argues, "The challenge is not just about teaching people to use the new technology, but to think critically about its application and to adapt to an evolving world" (Schleicher, 2020), This highlights the need to move beyond traditional TVET curricula and focus on equipping learners with the digital proficiencies and AI literacy essential for the modern workforce.

The integration of digital skills into TVET programmes is no longer an option, but a necessity. These skills, encompassing areas like data analysis, digital communication, cloud computing, cyber security, and online collaboration, provide the bedrock for innovation and productivity across all industries. UNESCO (2020) emphasizes in its report on TVET that digital literacy is now a fundamental requirement for participation in economic and social life. This underscores the essential role of these competencies in career progression and the ability to contribute meaningfully to the economy. Moreover, digital skills enable TVET institutions to adopt more effective and engaging teaching methodologies. Online learning platforms, interactive simulations, and virtual laboratories enable personalized instructions, catering to diverse learning styles and bridging geographical barriers. World Bank (2019) notes in its world Development Report 2019: The changing nature of work, technology can democratize education, making it more accessible and equitable globally, particularly in rural and underserved communities

Furthermore, AI can be integrated into TVET curricula to prepare students for careers in AI-related fields and sectors significantly impacted by AI. Brynjolfsson and McAfee (2014) highlight in their work, "The second machine Age", automation is reshaping the landscape of jobs," and TVET must evolve to train individuals to work alongside AI systems and in emerging AI- driven sectors. This requires updating programmes to include modules on AI ethics, machine learning, robotics, and data science.

The traditional landscape of work is being reshaped by automation and digitalization. TVET institutions which are crucial for producing skilled workforce must evolve to meet these new demands. This transformation requires incorporating, digital skills, proficiency in using digital tools, platforms, and technologies is now fundamental across various industries; TVET must equip learners with these skills to ensure employability and adaptability.

AI Literacy: understand the fundamentals of AI, its applications, and its potential impact is vital. TVET institutions should integrate AI- driving future. Economic Diversification: Countries can reduce their reliance on a limited number of industries by fostering new sectors powered by digital technologies and AI. TVET can play a key role in enabling this transition by training workers for emerging fields. The implications are clear: If TVET systems fail to adapt, economies risk will fall behind. This makes thorough exploration of this topic at academic conferences essential, and the lead paper sets the stages for that crucial discussion.

AI provides personalize learning experience, provides real-time feedback, automating assessment processes, analyzing labour market trends to adapt curriculum, and creating immersive virtual training simulations. Ultimately leading to more efficient and effective vocational training tailored to individual learner needs and industrial demands.

Overview of AI Tools in TVET

As the sun rises over a bustling classroom filled with students, the quiet hum of AI tools silently begins to reshape the landscape of education. According to a 2022 report by Mckinsey and company. The integration of AI in education is projected to reach a staggering 16 billion by 2024, transforming traditional learning system into personalized experiences for over 1.5 billion students worldwide. For instance, platforms like Duolingo have demonstrated that AI can increase language retention rates by 40%, while system like Carnegie Learning MATHIA have shown that personalized math tutoring can boost student performance by an astonishing 23% compared to conventional teaching methods. This evolution hints at a stricking reality.

Within this captivating narrative of educational transformation, an impressive array of tools emerges, each with its own unique capabilities. Consider Adaptive learning Technologies, which harness data from millions of student's interactions to formulate personalized learning paths that cater to individual strengths and weaknesses. A study from the Bill and Melinda Gates Foundation revealed that 80% of educators using AI-driven systems reported enhanced engagement among their students. Similarly, AI Chatbots like Jill Watson have taken on the rate of virtual teaching assistants, answering student questions and providing instantly, thus reducing instructor workloads by nearly 20%. As these tools evolve, educators and students alike are navigating a new frontier where learning is not just about acquiring knowledge but about unlocking each learner's full potential in an increasing complex world.

Benefits of Integrating AI in Training Programmes:

Integrating AI into training programmes has proven to be a game-changer for organizations seeking to enhance their workforce and productivity. For instance, companies that adopt AI in their training strategies reported a staggering 30% increase in employee engagement and retention rates, according to a 2022 study by the University of California. Imagine a scenario where an employee named Salah struggles to grasp a complex software tool during on boarding. With the implementation of AI-driven adaptive learning systems, Sarah receives personalized training modules tailored to her learning pace and style, allowing her to master the material more effectively and quickly than traditional methods. This innovational approach not only boosts her confidence but also reduces the average training time by up to 40%, propelling her toward peak performance in record time. As a result, businesses are not only cultivating evolving market place.

In understanding AI in technical education: As AI continues to reshape industries, its potential in technical education is exciting and transformative. This is the key to unlocking its benefits. This section explores how AI can enhance, not replace, traditional teaching, shares real- world success stories from TVET institutions, and addresses common misconceptions and concerns. Artificial intelligence (AI) is not a distant, futuristic concept, it is already here, transforming industries and education and training (TVET).

CHALLENGES AND SOLUTIONS WHEN USING TECHNOLOGIES IN THE CLASSROOM:

However, the integration of digital skills and AI into TVET is not without its challenges. One major obstacle is the digital divide, which limits access to technology and internet connectivity for many learners, particularly in developing countries. A more skilled workforce but also positioning themselves competitively in an every-technology is perhaps the strongest factor shaping the educational landscape today. Many school districts are showing support for increased levels of technology in the classroom by providing hardware such as tablets, computers, enhancing internet connectivity, and implementing programme designed to improve computer literacy for both teachers and students. Although teachers generally appreciate the benefits of educational technologies, they often find smooth and effective integration of the new educational technologies challenging. From acquisition of new technology equipment to adaptation of curricula and teaching techniques to incorporate new educational tools, technology integration presents significant challenges to educators at each level of school systems.

Some of common challenges faced by educators when attempting to integrate technology in the classroom, and offer potential solutions to those problems:

1. Insufficient equipment or connectivity, in terms of the access constraint. If there is no adequate computers, fast internet connection, the implementation of educational technology is not feasible, inadequate training related to technology. If teachers are not provided effective professional development on new technologies, they will not be capable of using it to its full potential. Fisher, Dwyer, and Yocam(1996) certainly, the most basic step toward effective technology integration is widespread access to equipment necessary to run educational computer programme. Warschauer, Zheng, Niiya, Cotton, and Farkas,(2014). Many students do not have regular and reliable access to a computer. Inconsistent computer access makes it difficult for instructors to integrate technology into existing lesson plans. Routine access to hardware ie labtops or tablets, software (reading and writing software, internet browsers), and internet con nection is a fundamental requirement. Schools must also be prepared with a network infrastructure that can accommodate the additional number of devices and that is appropriately secure (Afreen, 2014).
2. Training: Ertmer et. al (2012) stated that the most commonly cited reason for teachers' struggles with technology integration is inadequate professional development and training to keep their skills current.
3. Teacher Attitudes and Beliefs: Teachers' attitudes and beliefs are crucial factors in determining the role and effectiveness of technology in classrooms. Attitudes and beliefs about both educational technology and pedagogy in general will ultimately influence how teachers implement technology. Now that technology is being widely used in schools, the most important question is how to best

implement technology, rather than whether technology will be used (Ertmer et al. 2012).

4. Confidence in skills and knowledge: Given the abundance of available educational technology, it is essential that teachers feel comfortable and confident about their ability to use them effectively. Many current teachers grew up without access to technologies like the personal computer and the internet, but students today are raised in an environment saturated by computer technology.
5. Resistance to change from traditional pedagogical methods of teaching TVET to more innovative and technology-based teaching and learning methods.

In today" rapidly evolving job market, digital skills have become the cornerstone of career advancement and organizational success. A recent study by the World Economic Forum revealed that by 2025, 85 million jobs may be displaced due to the shifting division of labour between humans and machines. Conversely, the same report predicts that 97 million new roles to job could emerge, that are more adapted to the new digital landscape. This stack contract underscores the urgent needs for workers, especially those in traditionally non-digital roles, to acquire competencies such as data analysis, digital marketing, and cyber security. For instance, a LinkedIn analysis found that companies with a strong digital presence are 2.5 times more likely to be considered industry leaders, emphasizing the essential nature of digital fluency in enhancing business performance and competitive edge,- consider the story of a mid-sized manufacturing company that faced declining productivity due to outdated operational methods. After investing in digital skills training programmes for their workforce, where78% of employees reported an increase in their technical proficiency, the company saw a remarkable turnaround. Within one year, productivity soared by 25% and employee retention rates improved by 15%, as team members felt more equipped and valued in the digital age. This transformation aligns with research from Mckinsey, which stated that companies that invest in digital skills training can see an increase in team performance by up to 20%. In a world where agility and adaptability are paramount, the ability to navigate digital tools and platforms has become not just striving for success.

CONCLUSION:

TVET is not just an alternative to traditional education. It is a vital engine driving economic growth and diversification. By equipping individuals with practical skills, fostering innovation ,and supporting the growth of new industries, TVET plays a crucial role in enabling nations to thrive in a competitive global economy, investing in TVET is not just an investment in individual skills, it is an investment in a more prosperous and resilient future for all. As nations strive for sustainable economic growth and diversification, prioritizing and strengthening TVET systems must be a central strategic imperative. In conclusion integrating AI tools into digital skills training programmes represents a transformative shift in how we equip individuals for the demands of the modern workforce. By leveraging advance technologies these programmes can offer personalized learning experiences, adapt to diverse learning styles, and provide real-time feedback, thereby enhancing the overall efficacy of the training. As AI continues to evolve, it's potential to bridge skill gaps and foster greater accessibility to digital becomes increasingly significant. This integration not only empowers learners but also prepares them to thrive in an increasingly digital economy. Furthermore, the successful implementation of AI tools in training programmes necessitates a collaborative approach that involves educators, technologists, and industry stakeholders. It is crucial to ensure that the design and delivery of these programmes are aligned with the specific needs of the workforce and the communities they serve. By embracing this collaborative mindset, we can cultivate a

generation of learners who are not only proficient in digital skills but are also equipped with the critical thinking and problem solving abilities necessary to navigate the complexities of the future job market. The future of digital skills training lies in our ability to adapt and innovate, by making AI an essential ally in this ongoing journey. The effective integration of digital skills and AI in TVET is crucial for economic diversification and sustainable development in the 21th century.

RECOMMENDETIONS:

Based on the analysis of research presented, the following recommendations are relevant for policy- makers and practitioners.

1. There must be a strong collaboration between industry partners and educational institutions, to develop AI-powered training solutions that address specific skill gaps and industry needs. Instructors should be giving the opportunity for continuous skilling and re-skilling to meet up with those technological changes in industries, ensuring that they stay up-to-date with industry trends and technology.
2. All TVET instructors will be teachers of digital skills as effective agents in the propagation of digital literacy.
3. Transformational, learner- centered philosophies should be at the heart of technology- enabled learning. The quality and usefulness of ICT- enabled teaching and learning depends upon careful attention to the issues of accessibility and equitability, principles of adult learning and instructional design and appropriateness of the delivery and support services.
4. Personalized Learning; Use AI to create adaptive learning pathways that cater to individual students' needs, skills, and learning styles.
5. Intelligent tutoring systems: Implement AI –powered tutoring systems that provide real-time feedback, guidance, and support to students.
6. Simulation- based training: Utilize AI-driven simulation to provide students with hands-on experience in a controlled environment, enhancing their practical skills.
7. Automated assessment and feedback: Leverage AI to automate assessment and feedback processes, freeing up instructors' time and providing students with timely, accurate feedback.
8. Career guidance and counseling: Use AI-powered tools to provide students with personalized career guidance, recommending relevant courses, training, and job opportunities.
9. Data-driven decision making: Use AI analytics to inform decision-making, identify areas for improvement, and optimize TVET programmes.
10. Accessibility and inclusivity: Improvement AI-powered tools to support students with disabilities, language barriers, or other challenges, promoting inclusivity in TVET.
11. Monitoring and evaluation: Use AI to monitor and evaluate the effectiveness of TVET programmes, identifying areas for improvement and measuring student's outcomes.

    By embracing AI in TVET, educators can enhance student's learning outcomes, improve programs effectiveness. And better prepare students for the demands of the modern workforce.

SUB-THEME 1

ENTREPRENEURSHIP TECHNOLOGY

Integrating Digital Literacy and Artificial Intelligence in Technical and Vocational Education and Training (TVET) for Sustainable Economic Diversification in the 21st Century

Nnaemeka Martin Agbo[1], Anthony Osinachi Okorafor[2] & Samson Onyeluka Chukwuedo[3]

[1,2&3]Department of Industrial Technology Education, Nnamdi Azikiwe University, Awka

emails: [1]nm.agbo@unizik.edu.ng [2]ao.okorafor@unizik.edu.ng [3]so.chukwuedo@unizik.edu.ng

Abstract

As economies around the world confront shifting labour market dynamics, the imperative for sustainable economic diversification has become central to development discourse—particularly in resource-dependent nations. Technical and Vocational Education and Training (TVET) has been identified as a critical driver in equipping the workforce with adaptable, future-ready skills. With the Fourth Industrial Revolution (4IR) accelerating technological convergence, this review explores the pivotal role of digital literacy and artificial intelligence (AI) in transforming TVET into a catalyst for inclusive, diversified economic growth. Drawing on global literature and case examples, the paper discusses conceptual frameworks, key trends, policy imperatives, challenges, and transformative potentials of embedding digital literacy and AI within TVET ecosystems. It concludes with strategic recommendations for aligning TVET with the demands of the digital economy.

Keywords: Digital literacy, Artificial intelligence, Technical and Vocational Education and Training (TVET), Economic diversification, Sustainable development, Industry 4.0, 21st-century skills

1. Introduction

In an increasingly digital and knowledge-driven global economy, the capacity to leverage technological innovation has become a central determinant of national development and economic resilience. Particularly in the Global South, countries seeking sustainable economic diversification must reimagine education and training systems to equip the workforce with the digital competencies and technological adaptability required in the Fourth Industrial Revolution (UNESCO, 2023a; Khan *et al*, 2025; World Bank, 2021; Briken *et al*, 2017). Technical and Vocational Education and Training (TVET), with its practical orientation and workforce-centric curriculum, is uniquely positioned to bridge the skills gap between education and evolving labour market demands (Nkunya & Mwila, 2024; ILO, 2022).

Digital literacy—defined not merely as the ability to use digital tools, but as the capacity to critically engage with digital technologies and participate meaningfully in digital societies—has become a core skill for socio-economic empowerment (Reddy *et al,* 2023; Onwubuya & Agbo, 2025). Simultaneously, Artificial Intelligence (AI) is rapidly transforming industries, redefining job roles, and creating new pathways for automation, personalization, and productivity across sectors including agriculture, manufacturing, healthcare, and logistics (OECD, 2021; Mienye *et al,* 2024; Masriadi *et al,* 2024). These emerging technologies, if strategically embedded into TVET systems, offer unprecedented opportunities to drive inclusive economic growth and build innovation-driven economies.

In Nigeria and other sub-Saharan African nations, overdependence on extractive industries has revealed the fragility of mono-resource economies, especially in the face of global shocks such as fluctuating oil prices or pandemics (Adewumi & Yusuf, 2022; Ezeani & Mbah, 2023). Economic diversification—anchored on skills development in technology, manufacturing, creative industries, and digital entrepreneurship—is now imperative. TVET, empowered by

digital literacy and AI integration, can serve as the engine for producing a digitally competent, entrepreneurial, and future-ready workforce (UNESCO-UNEVOC, 2022; Nwokolo & Eze, 2021).

However, despite global momentum, challenges such as inadequate infrastructure, limited teacher capacity, policy inertia, and uneven access to digital tools continue to undermine the potential of TVET systems in many developing economies (Afemikhe & Ofuani, 2023; Pavlova, 2020). Moreover, the ethical implications of AI in education, including issues of bias, data privacy, and algorithmic governance, demand critical examination.

This review therefore explores current scholarship and policy discourse on the integration of digital literacy and artificial intelligence into TVET as a strategy for promoting sustainable economic diversification in the 21st century. Drawing on empirical studies, global frameworks, and best practices, it aims to provide a conceptual and strategic synthesis to guide policymakers, educators, and researchers in transforming TVET into a catalyst for inclusive and innovation-led growth.

2. Conceptual Clarifications

2.1 Digital Literacy

Digital literacy is more than just the ability to use computers or access the internet. It involves the critical skills to evaluate, interpret, and create digital content across various formats, ensuring informed decision-making and responsible use of technology (Onwubuya & Agbo, 2025; Reddy *et al*, 2023). In today's digital society, these skills form the foundation for digital citizenship, where individuals are expected to contribute ethically and responsibly to online communities (Hussain & Phulpoto, 2024; Reddy *et al.*, 2023).

Moreover, digital literacy is essential for lifelong learning, enabling individuals to adapt and acquire new skills in response to technological advancements. As the digital economy evolves, those who are digitally literate are better equipped to engage in self-directed learning and remain competitive in the job market (Morris & Rohs, 2021). In the context of Technical and Vocational Education and Training (TVET), it plays a critical role in enhancing employability by providing learners with the tools to innovate and meet industry demands in a rapidly changing technological landscape (UNESCO, 2023a).

2.2 Artificial Intelligence (AI)

Artificial Intelligence (AI) refers to the simulation of human intelligence processes by machines, particularly computer systems. These processes include learning, reasoning, self-correction, and the ability to interact with humans in ways that mimic human cognition (OECD, 2021; Roser, 2022). In the context of education, AI holds transformative potential by enabling personalized learning, where algorithms adapt content to meet the specific needs and learning styles of individual students. AI also facilitates predictive analytics, helping educators identify students who may need additional support or interventions based on their performance patterns. Furthermore, AI can streamline administrative tasks, such as grading, scheduling, and resource management, allowing educators to focus more on teaching and fostering student engagement (OECD, 2021; Wang *et al*, 2024).

In Industrial Technology Education (ITE), AI is increasingly used to enhance both learning and teaching outcomes. AI-powered tools can simulate real-world industrial environments, providing students with interactive and immersive experiences that are difficult to replicate in traditional classrooms. For example, virtual simulations powered by AI can recreate complex machinery operations, allowing students to practice troubleshooting and problem-solving in a

risk-free setting. Additionally, AI enables smart manufacturing and robotics training, offering students the opportunity to engage with automated systems and learn how AI-driven tools and machines optimize industrial processes. By incorporating AI into ITE, educators can equip students with the skills necessary to work in modern, technology-driven industries (OECD, 2021; Alexandrowicz, 2024).

2.3 Technical and Vocational Education and Training (TVET)

Technical and Vocational Education and Training (TVET) is an educational approach that equips learners with the knowledge, skills, and competencies required for specific trades, occupations, or vocations across various sectors of economic and social life (UNESCO-UNEVOC, 2022a; Agbo *et al*, 2024). Unlike traditional academic education, TVET is primarily practical and competency-based, focusing on hands-on experience and real-world application of skills. This approach ensures that learners are not only theoretically knowledgeable but also capable of performing tasks proficiently in their chosen fields. TVET is particularly valuable in preparing individuals for direct entry into the workforce, as it provides the practical, technical, and problem-solving skills that are in high demand in rapidly evolving industries. Furthermore, TVET programs are designed to be adaptable to changing industry needs, making them essential for sustainable economic development and addressing skills gaps in various sectors (UNESCO-UNEVOC, 2022a, Agbo & Nnajiofor, 2023). This makes TVET a cornerstone for equipping learners with employable skills and enhancing workforce productivity, particularly in economies seeking diversification and technological advancement.

2.4 Economic Diversification

Economic diversification involves the strategic expansion of an economy to encompass a broader array of sectors, industries, and value chains, thereby reducing its reliance on a narrow set of industries or commodities (Corinne *et al*, 2024). In developing economies, this process is particularly critical as it seeks to reduce dependence on primary commodities such as oil, agriculture, or mining, which are often subject to market volatility and external shocks. By diversifying, countries can mitigate risks associated with overreliance on these sectors and foster more resilient and sustainable economic growth. Key areas of investment for diversification include sectors like technology, education, manufacturing, and creative industries—sectors that not only provide opportunities for employment and innovation but also drive long-term productivity and competitiveness (World Bank, 2021; Ezeani & Mbah, 2023). Furthermore, economic diversification contributes to the development of new industries, job creation, and the promotion of technological advancements, ultimately enhancing a country's ability to withstand economic downturns and navigate the challenges of global economic shifts (World Bank, 2021).

3. Integration of Digital Literacy in TVET

Globally, digital literacy is being embedded into TVET curricula as a core competency for the modern workforce. In countries such as Finland, Germany, and Singapore, digital tools and platforms are used to enhance hands-on training, simulate industry processes, and facilitate distance learning (Lim *et al*, 2024; Breiter *et al*, 2021; Roll & Ifenthaler, 2021).

In sub-Saharan Africa, efforts have been made to integrate digital skills into TVET, but progress is uneven due to infrastructural and policy limitations (Afemikhe & Ofuani, 2023). In Nigeria, initiatives like the National Digital Economy Policy and Strategy (2020-2030) highlight the government’s intent to transform education through digital technologies. However, implementation in TVET institutions remains inconsistent.

Research by Nwokolo and Eze (2021) emphasizes the need for targeted investments in teacher digital upskilling, broadband expansion, and the inclusion of digital ethics and cybersecurity

in TVET curricula. Furthermore, UNESCO (2023) advocates for learner-centered digital learning environments that promote innovation, collaboration, and problem-solving.

4. Applications of Artificial Intelligence in TVET

AI is reshaping TVET delivery through intelligent tutoring systems, personalized learning pathways, and adaptive assessments (Bakar *et al,* 2025; Yarlagadda, 2025; McKinsey Global Institute, 2023a). Tools such as chatbots, virtual labs, and learning analytics platforms enhance engagement and provide real-time feedback, allowing educators to tailor instruction to individual learner needs.

However, AI adoption in TVET is still in its infancy in many developing contexts. Studies highlight concerns about the digital divide, data governance, and the need for ethical frameworks to guide AI deployment (Jiayan *et al,* 2024; Welamo *et al,* 2023; OECD, 2021). Without deliberate policy actions, AI could exacerbate inequalities rather than bridge them.

Integrating AI into TVET should therefore prioritize equity, transparency, and capacity building. Educators must be equipped with AI literacy, while students should learn not only to use AI tools but also to understand their implications for work, society, and ethics (UNESCO-UNEVOC, 2022b).

4.1 Artificial Intelligence Applications in TVET: African Context

In many developing countries, including Nigeria and several other African nations, AI adoption in TVET remains at a nascent stage. Despite the technological advancements globally, there are significant barriers in these regions that hinder the widespread implementation of AI in education. One of the main challenges is the digital divide, which is especially pronounced in rural and underserved urban areas where access to technology and the internet is limited or inconsistent. This divide not only restricts students' ability to access AI-powered educational tools but also limits their opportunities for digital literacy (OECD, 2021). Additionally, there are concerns related to data governance, as the infrastructure for securing and managing student data may not be well-established or adequately protected, leading to potential risks around privacy and cybersecurity (Kamenskih, 2022; Jiayan *et al,* 2024).

Furthermore, AI's integration in TVET is not just about technology adoption but also about ensuring that it is done ethically and inclusively. Without deliberate policy actions, there is a risk that AI could exacerbate inequalities rather than bridge them. For example, if AI is primarily deployed in more affluent or technologically advanced regions, marginalized groups may be left behind in terms of access to quality education and skills development (OECD, 2021). This potential for widening inequality underscores the need for a strategic, inclusive approach to AI integration in education, particularly in developing nations.

In Nigeria and much of sub-Saharan Africa, while there is growing interest in integrating AI technologies into education, several systemic and infrastructural challenges persist. These include unreliable electricity, insufficient digital infrastructure, and lack of trained personnel to design and manage AI-driven educational systems. Additionally, many educational institutions lack access to the necessary resources and expertise to train both educators and students in AI literacy. Thus, there is a pressing need for capacity building at multiple levels: from governmental and institutional leadership to educators and students themselves. This includes ensuring that AI literacy becomes an integral part of teacher professional development programs, enabling educators to both use and teach with AI tools effectively. Moreover, students should be encouraged not only to use AI tools but also to critically engage with them and understand their broader implications for work, society, and ethics (UNESCO-UNEVOC, 2022b).

As AI technologies continue to evolve, it is essential that African nations, including Nigeria, adopt inclusive, transparent, and ethical policies around AI in education. Governments, educational institutions, and private sectors must collaborate to ensure that AI tools are designed and implemented with a focus on equity, ensuring that all learners—regardless of socio-economic status or geographic location—have equal access to the benefits of AI-enhanced education. This could involve targeted policies to improve internet access, digital literacy programs, and AI-based curricula that prepare learners for future careers in emerging industries. By prioritizing capacity building, equity, and inclusivity, AI integration in TVET can become a powerful tool for sustainable economic development and skills training in developing countries (Welamo *et al,* 2023, ILO, 2024).

5. TVET and Economic Diversification: A Strategic Nexus

Technical and Vocational Education and Training (TVET) plays a crucial role in driving economic diversification, particularly by facilitating the shift from economies that are heavily reliant on natural resources to those that foster innovation and technology-driven growth. According to Nnajiofor et al (2017), the surest means of achieving economic diversification for economic development and sustainability is investing heavily on human capital. They further noted that TVET holds the key to productive workforce. As nations seek to reduce their dependence on primary commodities, TVET provides a technically skilled workforce that supports the development of key sectors such as Information and Communication Technology (ICT), renewable energy, agribusiness, and digital manufacturing. These sectors are central to sustainable economic development and job creation in emerging industries, making TVET a cornerstone for industrial development and entrepreneurship (ILO, 2022; Ezeani & Mbah, 2023). Through comprehensive skills training, TVET enables individuals to develop both technical expertise and innovative capabilities, equipping them to participate in and lead the industries of the future.

Empirical evidence from regions such as East Asia further underscores the transformative impact of aligning TVET reforms with national industrial strategies. Countries like South Korea, Singapore, and China have shown that well-structured TVET systems closely linked to national economic goals can catalyze industrial growth, create high-value jobs, and ensure that workforce skills match the evolving needs of the economy (OECD, 2023). This integration has allowed these nations to transition from primarily resource-based economies to technology-driven ones. The skills mismatch that often arises when TVET programs are not aligned with industry needs remains a challenge for many developing regions. In contrast, African countries frequently suffer from a policy disconnect between the labor market and educational outputs, leading to underutilization of TVET graduates and poor economic outcomes. The lack of coherent national strategies linking TVET with broader economic goals results in skills that are not sufficiently tailored to meet the needs of rapidly changing global industries.

For TVET to effectively catalyze economic diversification, there must be stronger linkages between industry and education systems. This includes the creation of innovation hubs that encourage research and development, public-private partnerships to address funding gaps, and a renewed focus on equipping students with green economy skills and digital capabilities that are essential for future growth. As industries worldwide embrace sustainability and digitalization, TVET systems must evolve to provide competencies that align with these changes. For instance, sectors like green energy, smart manufacturing, and data analytics require specific skill sets that are often lacking in current TVET curricula. Hence, the integration of AI and digital literacy into TVET is not merely an optional enhancement but a core enabler of economic transformation. The ability to utilize AI in manufacturing, agriculture, and service delivery, combined with robust digital literacy, can empower learners

to innovate within industries of the future and effectively contribute to the sustainability and competitiveness of their nations (UNESCO, 2023a).

Thus, as nations focus on economic diversification, it becomes imperative that TVET systems are modernized and aligned with industry needs. This alignment will not only enhance the employability of graduates but will also create a more resilient, competitive workforce capable of driving innovation, entrepreneurship, and sustainable growth across various sectors.

6. Practical Strategies for Integrating Digital Literacy and AI in the Nigerian Context

Integrating digital literacy and Artificial Intelligence (AI) into Technical and Vocational Education and Training (TVET) in Nigeria is vital for building a resilient, future-ready workforce. Given the evolving demands of the global digital economy, strategic interventions are necessary to embed these competencies sustainably within Nigeria's TVET system. This involves rejig of a number of things such as curriculum, infrastructure among others. Thus, the following provides practical steps to integrate digital literacy and AI in Nigeria:

Curriculum Modernization

To reflect 21st-century workforce requirements, TVET curricula should incorporate digital literacy and foundational AI concepts, including data literacy, algorithmic thinking, and the ethical use of AI. Modular and competency-based approaches should be adopted, with emphasis on real-world applications and problem-solving (UNESCO, 2022a; UNESCO, 2022b).

Teacher Upskilling and Capacity Building

Most TVET instructors in Nigeria lack the requisite knowledge to teach digital and AI-related skills. Training programs—delivered through workshops, online courses, and certifications—should be prioritized to equip educators with skills in AI tools, virtual learning environments, and data analytics (Dunya *et al,* 2025). Collaborations with tech firms and universities can accelerate this effort.

Investment in ICT and AI Infrastructure

Sustainable integration requires robust digital infrastructure, including internet access, smart classrooms, and AI-enabled tools like intelligent tutoring systems. Government and industry partnerships can help bridge infrastructure gaps through targeted funding, donations, and public-private partnerships (Agbo & Nnajiofor, 2023; Asamoah & Amarteifio, 2025).

Localization and Open Educational Resources (OERs)

Developing locally relevant digital and AI content using open-source platforms can reduce dependency on foreign tools. Resources should be tailored to Nigeria's socio-economic and cultural context to ensure accessibility and relevance (Adedokun-Shittu *et al*, 2023; Nhando, 2021).

AI-Enhanced Learning and Assessment

The deployment of AI technologies like adaptive learning platforms, intelligent tutoring systems, and predictive analytics can personalize learning, monitor student progress, and guide interventions. These tools can simulate industry tasks and improve learner engagement (Bakar *et al.*, 2025).

Inclusive Access and Gender Equity

Deliberate efforts must ensure that digital and AI initiatives in TVET reach underserved populations, including women, persons with disabilities, and rural communities. Strategies such as mobile-based learning, subsidized data plans, and community ICT hubs can bridge the digital divide (UNESCO, 2023b).

Policy Reform and Stakeholder Engagement

National policies must explicitly support digital and AI integration in TVET. This includes setting standards, providing incentives for innovation, and involving stakeholders—such as

employers, training institutions, and civil society—in co-designing solutions (Federal Ministry of Communications and Digital Economy, 2020).

7. Conclusion and Recommendations

Harnessing digital literacy and artificial intelligence in TVET represents a strategic pathway toward achieving sustainable economic diversification in the 21st century. While global exemplars provide valuable lessons, contextual realities in developing countries like Nigeria necessitate tailored strategies that address infrastructural, pedagogical, and policy constraints. This review recommends:

1. Mainstreaming digital and AI competencies into all levels of TVET curricula.
2. Strengthening educators' capacity through continuous professional development in digital pedagogy and AI applications.
3. Investing in digital infrastructure, especially in underserved regions.
4. Fostering industry-TVET linkages to ensure alignment with labor market trends.
5. Implementing ethical guidelines for AI use in educational settings to safeguard inclusivity and data privacy.

   By embracing these imperatives, TVET systems can be repositioned not only to respond to current technological disruptions but to drive inclusive, diversified, and sustainable economic development.

References

Adedokun-Shittu, N. A., Mejabi, O. V., Olasheinde-Williams, F. A. O., Yusuf, M. O., Abdul Raheem, M. A. O., Ahmed, M. A., & Ajani, H. A. (2023). Contextualising STEM Learning: The GLOCALISE Approach and Web Repository. *West African Journal of Open and Flexible Learning*, *12*(1), 1–20. https://wajofel.org/index.php/wajofel/article/view/238

Adewumi, A. O., & Yusuf, A. T. (2022). Rethinking Nigeria's economic diversification strategy in a post-oil era: The role of vocational and technical education. *Journal of African Development Studies, 18*(3), 45–60.

Afemikhe, O. A., & Ofuani, O. A. (2023). Challenges in implementing digital tools in Nigerian TVET institutions: A critical review. *African Journal of Educational Technology and Policy*, *6*(2), 101–118.

Agbo, N. M., Odiri, M. T., Auta, M. A., & Onwusuru, I. M. (2024). Impact of vocational guidance on career choice and employability of vocational and technical education students in a public university in Anambra State. *Asian Journal of Vocational Education and Humanities, 5*(1), 20-26. https://doi.org/10.53797/ajvah.v5i1.3.2024

Agbo, N.M. & Nnajiofor F.N. (2023). The role of university-industry linkage in creating a functional technical and vocational education and training (TVET) in Nigeria. *Journal of Vocational Educational Studies, 6*(1). https://doi.org/10.12928/joves.v6i1.7233

Alexandrowicz V. (2024). Artificial intelligence integration in teacher education: Navigating benefits, challenges, and transformative pedagogy. *Journal of Education and Learning, 13*(6). https://doi.org/10.5539/jel.v13n6p346

Asamoah, M.K., & Amarteifio, J. (2025). Overcoming barriers and ethical challenges in implementing intelligent tutoring systems in Ghanaian higher education. *Discov Educ 4*, 179. https://doi.org/10.1007/s44217-025-00593-5

Bakar, M. H. A. J., Ghafar, N. M., & Abdullah, F. (2025). Exploring the integration of artificial intelligence in technical and vocational education and training (TVET): Applications, benefits, challenges, and future prospects. *Borneo Engineering & Advanced Multidisciplinary International Journal*, *3*(3), 57-63. https://beam.pmu.edu.my/index.php/beam/article/view/189

Breiter, A., Howe, F., & Brüggemann, M. (2021). *Digital Literacy as Cross-sectional Competence in VET – A Case Study of a Network of German Vocational Schools.* ECER Conference Proceedings.

Briken, K., Chillas, S., Krzywdzinski, M., & Marks, A. (2017). *The new digital workplace: How new technologies revolutionise work*. Bloomsbury Publishing.

Corinne C.D., Giovanni M., Monique N., Papageorgiou C., Wang K., & Nikola S. (2024). Economic Diversification in Developing Countries – Lessons from Country Experiences with Broad-Based and Industrial Policies. *International Monetary Fund, 6*. https://doi.org/10.5089/9798400240201.087

Dunya, T., Aliyu, A. A., & Adeyi, A. A. (2025). Applications of Information and Communication Technology (ICT) in Teaching Mathematics in Nigeria: Challenges and Prospects. *Journal of Research in Education and Society (JRES) , 15*(3), 148–162. Retrieved from https://icidr.org.ng/index.php/Jres/article/view/1725

Ezeani, E. O., & Mbah, P. O. (2023). Economic diversification and sustainable development in Nigeria: Imperatives for policy reform. *Nigerian Journal of Policy and Development Studies, 9*(1), 89–106.

Federal Ministry of Communications and Digital Economy. (2020). *National Digital Economy Policy and Strategy (2020–2030)*. Federal Government of Nigeria.

Hussain, N., & Phulpoto, S., (2024). Digital Literacy: Empowering Individuals in the Digital Age. *Assyfa Learning Journal, 2*(2), 70-83. https://doi.org/10.61650/alj.v2i2.231

International Labour Organization (ILO). (2022). *Skills and the future of work: Strategies for inclusive and sustainable development*. ILO Publications. https://www.ilo.org

International Labour Organization, ILO, (2024). *AI Skilling for Chinese TVET Trainers Toolkit Practitioner Consultative Workshop Report.* Ministry of Human Resources and Social Security (China). https://www.ilo.org/resource/news/%E2%80%98ai-skilling-chinese-tvet-trainers-toolkit%E2%80%99-practitioner-consultative?utm_source=chatgpt.com

Jiayan C., Yuehao C., Xi C., Jiayi L., Yijun W., & Yiqun L. (2024). *Optimization Study of Higher Education Data Governance in the Era of AI.* In Proceedings of the 2023. International Conference on Information Education and Artificial Intelligence (ICIEAI '23). Association for Computing Machinery, New York, NY, USA, 708–712. https://doi.org/10.1145/3660043.3660169

Kamenskih A. (2022). The analysis of security and privacy risks in smart education environments. *Journal of Smart Cities and Society, 1*(1):17-29. https://doi:10.3233/SCS-210114

Khan M.I., Yasmeen T., Khan M., Hadi N.U, Asif. M, Farooq M., & Al-Ghamdi, S.G. (2025).Integrating industry 4.0 for enhanced sustainability: Pathways and prospects. *Sustain. Prod. Consum., 54*,149-189, https://doi.org/10.1016/j.spc.2024.12.012

Lim, Z. Y., Yap, J. H., Lai, J. W., Mokhtar, I. A., Yeo, D. J., & Cheong, K. H. (2024). Advancing Lifelong Learning in the Digital Age: A Narrative Review of Singapore's Skills Future Programme. *Social Sciences, 13*(2), 73. https://doi.org/10.3390/socsci13020073

Masriadi, Dasmadi, Ekaningrum, N. E., Hidayat, M. S., & Yuliaty, F. (2023). Exploring the Future of Work: Impact of Automation and Artificial Intelligence on Employment. *ENDLESS: INTERNATIONAL JOURNAL OF FUTURE STUDIES, 6*(1), 125–136. https://doi.org/10.54783/endlessjournal.v6i1.131

McKinsey Global Institute. (2023a). *AI and the future of work: Implications for education and skills*. McKinsey & Company. https://www.mckinsey.com/featured-insights/future-of-work

McKinsey Global Institute. (2023b). *The economic potential of generative AI: The next productivity frontier*. https://www.mckinsey.com/mgi

Mienye I. D., Sun Y., & Ileberi E. (2024). Artificial intelligence and sustainable development in Africa: A comprehensive review, Machine Learning with Applications, 18. https://doi.org/10.1016/j.mlwa.2024.100591.

Morris T.H & Rohs M. (2021). Digitization bolstering self-directed learning for information literate adults–A systematic review. *Computers and Education Open 2*. https://doi.org/10.1016/j.caeo.2021.100048

Nhando, D. (2021). Utilizing open educational resources to advance online learning in Sub-Saharan Africa. *eLearning Industry*. https://elearningindustry.com/utilizing-open-educational-resources-advance-online-learning-sub-saharan-africa

Nkunya H.R. & Mwila P.M. (2024). Bridging the gap between TVET skills and labor market demands: An analysis of training outcomes in Dar Es Salaam, Tanzania. (2025). *International Journal of Research and Innovation in Social Science*. https://dx.doi.org/10.47772/IJRISS.2024.8120057

Nnajiofor, F. N., Okorafor, A. O. & Wogu, S. N. (2017). Technical, Vocational Education and Training for Economic Development and Sustainability beyond Oil in Nigeria. International Journal of Science and Technology, 6 (8) 875 – 880.https://www.researchgate.net/publication/330280743_Technical_Vocational_Education_and_Training_for_Economic_Development_and_Sustainability_beyond_Oil_in_Nigeria

Nwokolo, C. N., & Eze, A. N. (2021). TVET and youth empowerment in the digital economy: Emerging perspectives from Nigeria. *Journal of Technical and Vocational Studies*, *11*(2), 77–93.

OECD. (2021). *AI in education: Challenges and opportunities*. Organisation for Economic Co-operation and Development. https://www.oecd.org/education/ai-in-education

Onwubuya, U. N., & Agbo, N. M. (2025). Influence of digital workplace on the job performance of secretaries in public universities in Anambra State. *African Journal of Educational Management, Teaching and Entrepreneurship Studies*, *14*(2). Retrieved from https://www.ajemates.org/index.php/ajemates/article/view/689

Organisation for Economic Co-operation and Development (OECD). (2021). *AI and the future of skills: Challenges for education systems*. https://www.oecd.org/education/

Pavlova, M. (2020). *Bringing TVET up to Speed: Regional Overview of ICT-Enhanced Practices in TVET*. In: Panth, B., Maclean, R. (eds) Anticipating and Preparing for Emerging Skills and Jobs. Education in the Asia-Pacific Region: Issues, Concerns and Prospects, vol 55. Springer, Singapore. https://doi.org/10.1007/978-981-15-7018-6_24

Reddy P., Chaudhary K., & Hussein S., (2023). A digital literacy model to narrow the digital literacy skills gap. *Heliyon*, *9*(4). https://doi.org/10.1016/j.heliyon.2023.e14878

Roll, M.J.J., Ifenthaler, D. (2021). Multidisciplinary digital competencies of pre-service vocational teachers. Empirical Res Voc Ed Train 13 (7). https://doi.org/10.1186/s40461-021-00112-4

Roser, M. (2022). The brief history of artificial intelligence: the world has changed fast—what might be next? *Our world in data*. https://ourworldindata.org/brief-history-of-ai

UNESCO. (2022a). *Artificial Intelligence and education: A guidance for policymakers*. Paris: UNESCO.

UNESCO. (2022b). *Digital transformation of TVET and skills development systems in Africa*. IIEP-UNESCO Dakar. https://doi.org/10.54675/SXKY1636

UNESCO. (2023a). *Reimagining our futures together: A new social contract for education*. United Nations Educational, Scientific and Cultural Organization. https://unesdoc.unesco.org/

UNESCO. (2023b). *Enhancing TVET through digital transformation in developing countries*. UNESCO-UNEVOC. https://unesdoc.unesco.org/ark:/48223/pf0000385988

UNESCO-UNEVOC. (2022a). *Transforming TVET for a sustainable future: Key trends and recommendations*. https://unevoc.unesco.org/

UNESCO-UNEVOC. (2022b). *AI and TVET: Ensuring equitable access and opportunities*. United Nations Educational, Scientific and Cultural Organization. https://unevoc.unesco.org/

United Nations Educational, Scientific and Cultural Organization, UNESCO,. (2023). *Enhancing TVET through digital transformation in developing countries*. https://gcedclearinghouse.org/sites/default/files/resources/240428eng.pdf

Wang, S., Wang, F., Zhu, Z., Wang, J., Tran, T., & Du, Z. (2024). Artificial intelligence in education: A systematic literature review. *Expert Systems with Applications*, *252*, 124167. https://doi.org/10.1016/j.eswa.2024.124167

Welamo, T., Deng, S., & Shao, C. (2023). Relevance/importance of artificial intelligence in teaching vocational education and training: Case study at Ethiopia Federal TVET Institute. *International Journal of Engineering Research & Technology (IJERT)*, 12(07).

World Bank. (2021). *World development report 2021: Data for better lives*. World Bank Publications. https://www.worldbank.org/

Yarlagadda K.C. (2025). AI in Education: Personalized Learning and Intelligent Tutoring Systems, *European Journal of Computer Science and Information Technology, 13* (32), 15-27. https://doi.org/10.37745/ejcsit.2013/vol13n321527

LEVERAGING NIGERIA'S UNEMPLOYMENT CRISES THROUGH ARTIFICIAL INTELLIGENCE-DRIVEN SKILLS FOR ECONOMIC TRANSFORMATION

[1]Ogbondah N. CHUKUIGWE, [2]Dr. Baritule P. SAUE, [3]Chidi E. EBERE & [4]Dr. Ekwueme ORIKOHA

[1,3&4]Department of Industrial Technology Education, Rivers State University Port Harcourt
[2]Department of Metalwork Technology, Federal College of Education (Tech) Akoka, Lagos

Correspondence E-mail & Phone No: sauegodslead@gmail.com **(07039182970)**

ABSTRACT

The study was carried out on leveraging Nigeria's unemployment crises through acquisition artificial intelligence-driven skill for economic transformation. Two (2) objectives and research questions were posed to guide the study and answered by the respondents. The study adopted a survey research design because data were collected with the use of questionnaire. The population of the study was one hundred and twenty-two (122) lecturers drawn from the four (4) public universities in Lagos States, Nigeria. No sample was taken as the entire population was studied because of manageable size. A five-point Likert structured questionnaire designed on option the Strongly Agree (SA) =5, Agree (A) =4, Undecided (U) =3, Disagree (D) =2 and Strongly Disagree (1) =1, was deployed in eliciting data from the respondents. The instrument's validity was examined by three (3) experts from Tai Solarin University of Education, Ogun State using the face and content technique. Also, the instrument was found to be reliable after a test-retest method was conducted and evaluated using the Cronbach Alpha reliability test for internal consistency, where an alpha level of .73 was recorded, indicating a strong consistency level. The one hundred and twenty-two (122) copies of the questionnaire that were disseminated, retrieved and used in the analysis. Upon retrieval of instrument, the researcher analyzed the responses of respondent using bar chart to represent the degree of respondents' opinion. The study found that the respondents collectively recognize that artificial intelligence- driven, skills as highlighted in Table 1, are crucial to addressing unemployment in Nigeria. Recommendation reach is that for effectiveness in transition to AI-driven economy, Nigeria must invest huge in skilling, re-skilling and upskilling programmes while ensuring that the current workforce is not left behind.

Keywords: Unemployment, Artificial Intelligence, Skill Development, Economic Transformation

Introduction

Nigeria is a densely populated country with approximately 200 million people making it the most populous country in Africa and the 6th most populous country in the world. Life expectancy as of 2018 was 59 years (United Nations, Department of Economic and Social Affairs, Population Division (UNDESAPD, 2018a). The population demographic in Nigeria skews young with almost 60% of Nigerians below 24 years old leaving the country with a high dependency ratio (UNDESAPD, 2019). Furthermore, the population continues to grow rapidly thanks to an annual population growth rate of 2.5% leaving Nigeria on track to double its population in just 30 years and become the third most populous country in the world. The country according to World Bank (2021), has seen a contraction of its economy over the past few years thanks to declining oil prices and the recent COVID-19 crisis, although it began to

rebound in the 4th quarter of 2020, and also through the introduction of smart manufacturing in industries, leading to increased unemployment.

Nigeria's unemployment rate has reached alarming levels, prompting calls for innovative solutions to tackle this pressing issue. The Nigerian education system had also contributed enormous unemployment rate. Nigeria's unemployment rate rose to 4.2 per cent in Q2 2023 from the 4.1 per cent recorded in Q1 2023, quarterly Labour Force Survey (LFS) for Q2 2023 (National Bureau of Statistics 2023). According to the NBS, the unemployment rate is the percentage of the labour force that is actively looking for work but cannot find it. The system is built on grammar oriented and preference to paper certification. Other flaws in the education industry as contributor to this social menace includes examination malpractice, incessant strikes and lack of professionalism (Igwesi, 2016). Nigeria, with its significant youth population, must address the dual challenge of harnessing the potential of its human capital while simultaneously mitigating the risks of technological unemployment (National Bureau of Statistics, 2021). With a rapidly growing youth population, the education system must adapt to provide relevant skills to improve employability. The urgency for this becomes clear considering the potential of AI to both eliminate traditional jobs and create new ones that require advanced competencies (World Economic Forum, 2021).
According to the report of the National Bureau of Statistics (NBS, 2023), the rate of unemployment in Nigeria has increased to 42% as a result of the failed Cash Crunch Policy of the Central Bank and other factors. This situation is projected to skyrocket due to recent Premium Motor Spirit (PMS) subsidy removal by the Federal Government. Unemployment is a critical issue that affects economies and societies worldwide. According to a comprehensive study by Bell and Blanchflower (2019), the causes of unemployment are multifaceted and include structural, cyclical, and individual-level factors.

The development of Artificial Intelligence (AI) systems and technologies in what has been referred to as the "4th Industrial Revolution" has ushered in new opportunities and threats to developing countries. Scholars like Lee, *et al.*, (2018) emphasized that artificial intelligence is used in factories to allow the predictive management of sensitive industrial machineries to predict asset failure in Industry 4.0. The administration is helped to timely rehabilitate the facilities to avoid expensive unplanned downtime. The term 'AI' or 'AI system' describes digital and/or data-driven technologies, such as those used for automated decision making, diagnosis, predicting and forecasting, and pattern recognition. More so, Dal-mas, *et al.*, (2019); noted that with artificial intelligence implementation, industries can now take fast, data-driven decisions, simplify production processes, minimize operating costs and enhance customer service AI technologies hold great promise to address sustainable development goals (SDGs) particularly goal eight (8) which is to promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all. This could be effective through acquisition of appropriate skills that align with the current industry demands.

Skill acquisition enhances entrepreneurial ability and knowledge through structural training and institution building programmes which basically aim at enlarging the base of entrepreneur in order to hasten the pace at which new business are created. As the global labor market undergoes rapid transformations due to advancements in Artificial Intelligence (AI), the concept of employability is evolving. Traditional skills remain important but are increasingly complemented by a need for digital literacy and AI-related competencies. Isaac (2011) described skill as the panacea for eradicating extreme poverty and hunger by creating avenues for financial independence, job and wealth creation, while instilling self-sufficiency and reliance in the trainee. Ikegwu et.al (2014) opined that, skills acquisition and entrepreneurship

programmes are the first step in the fight for the reduction of unemployment, poverty and hunger in the society and these would lead to elimination of crime and other social vices. Skill acquisition has been conceived as an effective and efficient tool for self-reliance and sustainability of skills. The whole notion is that, young people should acquire skill training mechanism in addition to their regular academic programme/ curriculum in the crucial sectors in order to remain relevant in this contemporarily competitive world. National Directorate of Employment (2019) note that evidence abound that skills acquisition and entrepreneurship programmes have been of significance in addressing the problems associated with unemployment and poverty among the Nigerian youths, as it helps them to be gainfully employed and wealth creators. Skill acquisition has been conceived as an effective and efficient tool for self-reliance and sustainability of skills. The whole notion is that, young people should acquire skill training mechanism in addition to their regular academic programme/curriculum in the crucial sectors in order to remain relevant for economic transformation in this contemporarily competitive world.

Transformation as postulated by Olsson *et al.,* (2014), focuses on maintaining the existing economic system by increasing productivity and value-added. Economic transformation has emerged as a global concern among economists in recent decades. Weldegiorgis, et al. (2024) asserted that successful economic transformation depends on the efficient allocation and use of a country's resources, which, in turn, contributes to sustainable economic development. According to Song *et al.,* (2022) implies that economic transformation becomes a pivotal strategy for economic development, addressing key agendas such as marketization, globalization, and decentralization to enhance a nation's competitiveness. Economic transformation has been extensively explored in the literature. McMillan et al. (2017) maintained that economic transformation as a dynamic process involving two primary strategies including structural change through the reallocation of labor and resources from low-productivity to high-productivity sectors and the optimization of economic growth by prioritizing strategic sectors underpinned by science-based technology. Similarly, Weldegiorgis, et al. (2024) posited that economic transformation as a structural change driven by resource reallocation, resulting in enhanced productivity, economic diversification, and industrialization.

Statement Of Problem

The rapid integration of Artificial Intelligence (AI) into various sectors has exposed significant skill gaps in the current workforce, posing a substantial challenge to maximizing AI's potential benefits. Dwivedi et al. (2014) emphasize that while AI technologies advance at an unprecedented pace, the workforce's ability to keep up with these advancements is lagging. This disparity creates a pressing need for specialized skills in AI and data science that many employees currently lack (Sotala, 2012). Similarly, the study of Autor (2015) showed that the most notable skill gaps are in areas such as machine learning, data manipulation, and AI ethics. These skill gaps have been attributed the major causes of unemployment crises in recent times in Nigeria. Supporting the assertion above, Brynjolfsson and McAfee (2014) emphasize the need for continuous learning and adaptability to bridge these skill gaps, as the workforce's current abilities lag behind the rapid advancements in AI technology. This evolution in job roles necessitates a strategic focus on developing a skilled workforce, which includes not only technical proficiency but also the ability to apply AI insights in practical, industry-specific contexts (Yang, *et al.,* 2017). Furthermore, many employees lack necessary AI skills to work effectively with industry 4.0 technologies, which is the hub of the current unemployment faced in the country (author). To this end, the present study "leveraging

Nigeria's unemployment crises through artificial intelligence-driven skill for economic transformation" was conducted to investigate:

1. Artificial intelligence-driven skills that could leverage unemployment in Nigeria.
2. The impact of AI-driven skill on economic transformation of Nigeria.

Research Questions

Two (2) research questions guided the study

1. What artificial intelligence-driven skills could leverage unemployment in Nigeria?
2. What is the impact of AI-driven skill on economic transformation of Nigeria?

Methodology

The study adopted a survey research design because data were collected with the use of questionnaire. The population of the study was one hundred and twenty-two (122) lecturers drawn from the four (4) public universities in Lagos States, Nigeria. The population was made up of only mechanical engineering and technology lecturers from University of Lagos, Lagos State University, Lagos State University of Education, Lagos State University of Science and Technology. No sample was taken as the entire population was studied because of manageable size. A five-point Likert structured questionnaire designed on option the Strongly Agree (SA) =5, Agree (A) =4, Undecided (U) =3, Disagree (D) =2 and Strongly Disagree (1) =1, was deployed in eliciting data from the respondents. The instrument was administered on the respondents with the help of three (3) assistants and retrieved within an interval of fourteen (14) working days. The instrument's validity was examined by three (3) experts from Tai Solarin University of Education, Ogun State using the face and content technique. Also, the instrument was found to be reliable after a test-retest method was conducted and evaluated using the Cronbach Alpha reliability test for internal consistency, where an alpha level of .73 was recorded, indicating a strong consistency level. The one hundred and twenty-two (122) copies of the questionnaire that were disseminated, were retrieved and used in the analysis. Upon retrieval of instrument, the researcher analyzed the responses of respondent using bar chart to represent the degree of respondents' opinion.

RESULTS

Research Question 1: What artificial intelligence-driven skills could leverage unemployment in Nigeria?

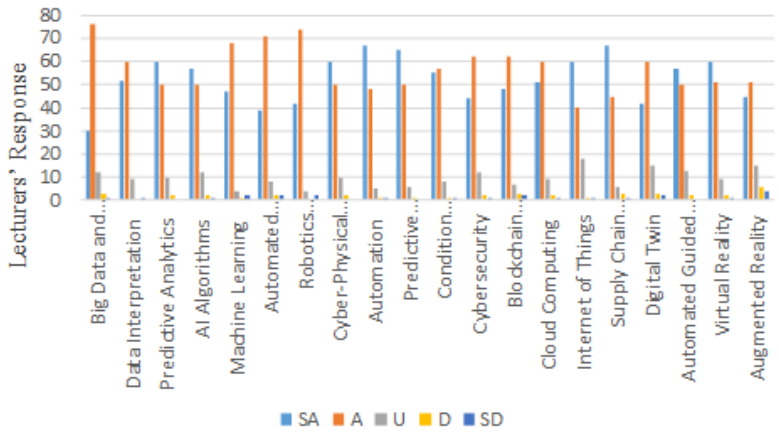


Figure 1. Presentation of Respondents' Responses on Artificial Intelligence-Driven Skills could Leverage Unemployment in Nigeria.

Source: Authors' Fieldwork (2025)

Table 1 presents the feedback from university lecturers across four (4) public universities in Lagos State, Nigeria, that offer mechanical engineering and technology courses. Twenty items were provided, and respondents expressed varying levels of agreement, from strongly agree to strongly disagree. The data in Table 1 indicate that lecturers strongly agreed was the major response in items 3, 4, 8, 9, 10, 15, 16, 18, and 19, while agreed was the major response in items 1, 2, 5, 6, 7, 11, 12, 13, 14, 17, and 20. This suggests that the respondents collectively recognize that artificial intelligence-driven skills such as big data and analytics, data interpretation, predictive analytics, ai algorithms, machine learning, automated machine learning, robotics engineering, cyber-physical systems skills, automation, predictive maintenance, condition monitoring, cybersecurity, blockchain technology, cloud computing, internet of things, supply chain management, digital twin, automated guided vehicle, virtual reality and augmented reality are could leverage unemployment crises in Nigeria.

Research Question 2: What is the impact of AI-driven skill on economic transformation of Nigeria?

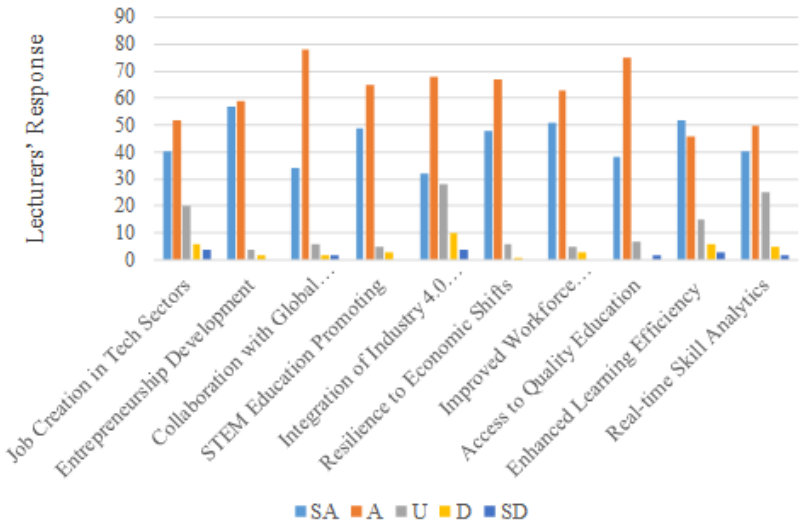


Figure 2. Presentation of Respondents' Responses on the Impact of AI-driven Skill Acquisition on Economic Transformation of Nigeria

Source: Authors' Fieldwork (2025)

Table 2 illustrates the feedback from university lecturers across four (4) public universities in Lagos State, Nigeria, which offer mechanical engineering and technology courses. The table includes ten items that were rated by respondents on a scale ranging from strongly agree to strongly disagree. The findings in Table 2, fig 2 indicate that "strongly agree" was the top response for item 9, while "agree" was the highest response for items 1, 2, 3, 4, 5, 6, 7, 8 and 10. The finding revealed that the respondents vividly agreed that artificial intelligence-driven skill acquisition has great impact on economic transformation of Nigeria through job creation in tech sectors, entrepreneurship development, collaboration with global institutions, stem education promoting, integration of industry 4.0 technologies, resilience to economic shifts, improved workforce competitiveness, access to quality education, and enhanced learning efficiency and real-time skill analytics.

Discussionof Results

Table 1 presents the feedback from university lecturers across five universities in Lagos State, Nigeria, that offer mechanical engineering and technology courses. Twenty items were

provided, and respondents expressed varying levels of agreement, from strongly agree to strongly disagree. The data in Table 1 indicate that lecturers strongly agreed was the major response in items 3, 4, 8, 9, 10, 15, 16, 18, and 19, while agreed was the major response in items 1, 2, 5, 6, 7, 11, 12, 13, 14, 17, and 20. This suggests that the respondents collectively recognize that artificial intelligence-driven skills such as big data and analytics, data interpretation, predictive analytics, ai algorithms, machine learning, automated machine learning, robotics engineering, cyber-physical systems skills, automation, predictive maintenance, condition monitoring, cybersecurity, blockchain technology, cloud computing, internet of things, supply chain management, digital twin, automated guided vehicle, virtual reality and augmented reality are could leverage unemployment crises in Nigeria. The finding is in consonance with Spanaki et al. (2017), who identified the rising demand for specialized AI skills as organizations integrate these technologies into their operations. This finding also aligns with Usoro (2010), who found that the failure of Nigeria's higher educational institutions is hinged on their products' (graduates) lack of the skills required by the labour market and that the trend had resulted in mass graduate unemployment, since they would have assisted them to be self-reliant.

Table 2 illustrates the feedback from university lecturers across five universities in Lagos State, Nigeria, which offer mechanical engineering and technology courses. The table includes ten items that were rated by respondents on a scale ranging from strongly agree to strongly disagree. The findings in Table 2, fig 2 indicate that "strongly agree" was the top response for item 9, while "agree" was the highest response for items 1, 2, 3, 4, 5, 6, 7, 8 and 10. The finding revealed that the respondents vividly agreed that artificial intelligence-driven skill acquisition has great impact on economic transformation of Nigeria through job creation in tech sectors, entrepreneurship development, and collaboration with global institutions, stem education promoting, integration of industry 4.0 technologies, resilience to economic shifts, improved workforce competitiveness, access to quality education, enhanced learning efficiency and real-time skill analytics.

Conclusion

In present-day Nigeria, unemployment has significantly impacted the nation's economy, leading to serious repercussions for its citizens. Many traditional skilled workers have become unemployed due to advancements in technology and the rise of artificial intelligence in what are referred to as "smart industries." This situation urgently needs to be addressed to mitigate the effects of unemployment on the Nigerian economy. Consequently, this study supports the idea that AI-driven skills development could serve as a transformative measures to Nigeria's unemployment crisis. The analysis of the findings indicated that respondents collectively see the potential of AI-driven skills, as outlined in Table 1, to help reduce unemployment in Nigeria. Additionally, Table 2 reveals that respondents largely agree on the significant positive influence of AI-driven skills on Nigeria's economic transformation.

Recommendations

The following recommendations were proposed leverage

1. For effectiveness in transition to AI-driven economy, Nigeria must invest huge in skilling, re-skilling and upskilling of students in AI-training programmes while ensuring that the current workforce is not left behind.
2. Integrate artificial intelligence tools into of lecturers to efficiently use AI in practice would enhance economic transformation by arming graduates with relevance skills for the world-of-works.

3. Collaborate with industry stakeholders to ensure skill development aligns with market needs while advocating for government policies that promote technological integration in education.

References

Autor, D. H. (2013). The "task approach" to labor markets" An overview. *Journal for Labour Market Research, 46*(3), 185-199.

Bell, D. N. F. & Blanchflower, D. G. (2011). Youth unemployment in Europe and the United States. *Nordic Economic Policy Review, 1*, 11-37

Bughin, J. Seong, J. Manyika, J. Chui M. and Joshi, R. (2020). *"Notes from the AI frontier: Modeling the impact of AI on the world economy", McKinsey Global Institute, 2018.* https://www.mckinsey.com/featured-insights/artificial-intelligence/notes-from-the-ai-frontier-modeling-the-impact-of-ai-on-the-world.

Delmas, A.; Sallak, M.; Schön, W.; Zhao, L. (13^{th} –15^{th} June, 2018). Remaining useful life estimation methods for predictive maintenance models: Defining intervals and strategies for incomplete data. In Proceedings of the 10th IMA International Conference on Modelling in Industrial Maintenance and Reliability, Manchester, 48–53. UK.

Dwivedi, Y. K., Wastell, D., Laumer, S., Henriksen, H. Z., Myers, M. D., Bunker, D., Elbanna, A. R., Ravishankar, M. N., & Srivastava, S. C. (2014). Research on information systems failures and successes: Status update and future directions. *Information Systems Frontiers*, *17*(1), 143-157.

Gillham, J. (2018). "The macroeconomic impact of artificial intelligence" PricewaterhouseCoopers.

Gumbari, J. (2011). *The importance of skills acquisition: A challenge to Nigerian Legislator. The national Assembly Legislative Digest.* http://www.nasslegislativeonline.com/newsde

Igwesi, N. (2016). *Education and society in Nigeria: A sociological perspectives*: Emkhai Publishers

Ikegwu, E.M.; Ajiboye, Y.O., Aromolaran, A.D.; Ayodeji, A.A. & Okorafor, U. (2014). Human empowerment through skill acquisition: Issues, impacts and consequences. A nonparametric view. *Journal of poverty, investment and development, 5*(1), 94-101

Isaac, N. (2011). *Skills acquisition: Tonic for economic empowerment.* http:// leadership.ng/nga/articles/163/2011/05/22skills-acquisition-toniceconomic.html

Lee, C., Cao, Y. & Ng, K., (2017). Big data analytics for predictive maintenance strategies, 50-74

McMillan, M.; Page, J.; Booth, D. & Velde, D.W. (2017). Supporting economic transformation: An Approach paper; supporting economic transformation: London, UK,

National Bureau of Statistics (2021). Labor force statistics: Unemployment and underemployment report. National Bureau of Statistics, Nigeria

National Bureau of Statistics (NBS, 2023). *Poverty and inequality in Nigeria: Executive summary.* NBS press

National Directorate of Employment. (2019). *National directorate of employment handbook*. Planning, Research and Statistics Department, National Directorate of Employment.

Olsson, P.; Galaz, V.; Boonstra, W.J. (2014). Sustainability transformations: A resilience perspective. Ecol. Soc, 19, 1–13.

Osita, F.C., Oraegbunam, P.O. & Onuzulike-Chukwuemeka, N. (2022). Curbing youth unemployment in South-East, Nigeria through skill acquisition and entrepreneurial education. *International Research Journal of Advanced Engineering and Science, 7*(4), 150-155

Song, C.; Yin, G.; Lu, Z.; Chen, Y. (2022). Land use efficiency in the yellow river basin in the background of China's economic transformation: Spatial-temporal characteristics and influencing factors. *Environmental Science Pollution Research, 29*, 4334–4349

Sotala, K. (2012). Advantages of artificial intelligences, uploads, and digital minds. *International Journal of Machine Consciousness, 04*(01), 275-291

Spanaki, K., Gurguc, Z., Adams, R., & Mulligan, C. (2017). Data supply chain (DSC): Research synthesis and future directions. *International Journal of Production Research, 56*(13), 4447- 4466

United Nations, Department of Economic and Social Affairs, Population Division (2018a). *World urbanization prospects*. https://population.un.org/wup/.

United Nations, Department of Economic and Social Affairs, Population Division (2019). *World Urbanization Prospects*. https://population.un.org/wup/.

Usoro E. B. (2010). Developing human resources in tertiary business education for youth empowerment and national development in Nigeria. *Review of Higher Education in Africa, 2*(1), 13-23

World Bank (2021). Resilience through reforms: Nigeria development update presentation (English). Nigeria Development Update. http://documents.worldbank.org/curated/en/

World Economic Forum (2021). *The future of jobs report 2021*. World Economic Forum

Yang, J., Chen, Y., Huang, W., & Li, Y. (2017). *ICAC - Survey on artificial intelligence for additive manufacturing.* [Paper presentation]. 23rd International Conference on Automation and Computing (ICAC), 1-6.

SUB-THEME 2

ELECTRICAL/ELECTRONICS TECHNOLOGY

Li-Fi ELECTRO-TECH WIRELESS COMMUNICATION FOR REVOLUTIONIZING INFORMATION TRANSMISSION IN OIL/ GAS FIELD OPERATION AMONG IOCs

Eric Nwabueze Ogbuji and Christian Okwukwu
Department of Electrical Electronic Technology Education, Federal College of Education (Tech) Omoku, Rivers State, Nigeria. Authors Email: enogbuji@gmail.com

Abstract
This study examined Li-Fi electro-tech wireless communication for revolutionizing information transmission in oil/ gas field operation among iocs. Two objectives, two questions guided the study. A survey research design was employed. The population comprised of 432 supervisory control and data acquisition personnel from oil/gas companies in Nigeria oil producing states. 56 participants were sampled for the study. Unstructured focused group online-based interview was used for data collection. Data was analyzed using thematic-coding and percentage. The study discovered that, transceiver block that acts as both a transmitter and a receiver consists of LED to transmit light and photodiode to receive the light, OFDM Technique as a modulation method provides multiple dimensional modulation to increase efficiency and performance in oil/gas field operation among others. Therefore, it was recommended for a Multi-Modulation circuit that handle rapid flicking state data transmission in low rate lighting.

Keywords: Li-Fi, wireless communication, information transmission, oil/gas operation.

Introduction

In recent times, electronic technology has taken the central stage as nothing can be organized and executed with better achievement without its application, more particularly in the oil and gas industry. This has informed the uprising of Li-fi electronic technology system in oil and gas exploration and exploitation internationally. According to Weiya and Lixin (2004) electronic technology has promoted the rapid development of human society, and created a huge economic wealth for the people, made a great contribution to improve the production efficiency, improve the living standards of the people.

An integral part of understanding electronic technology is the realization that LiFi is indispensable part of electronic technology in wireless communication. The world LiFi is coined from Light Fidelity. Raafat, Simon and Nizar (2015) defined Light fidelity (Li-Fi) as a new short range optical wireless communication technology which provides the connectivity within a local network, by using Light-Emitting Diodes (LEDs) to transmit data depending on light illumination properties.

Transfer data from one place to another is one of the most important day-to-day activities. The present wireless network that connects people to the internet is very dawdling when multiple devices are connected. As the number of devices that access the internet increases, the fixed bandwidth available makes it more difficult to enjoy high data rates and connect to a secure network. Raafat, Simon and Nizar (2015) noted that recently, everyone is interested in using their electronic devices to communicate with other people through Wireless-Fidelity (Wi-Fi) systems, and this technology, Wi-Fi, is widely used in all public areas such as home, cafes, hotels and hospitals. The authors investigated that In order to overcome this problem in the future, Professor Harald Haas, an expert in optical wireless communications, proposes in 2011 a brilliant and applicable solution by using light to transmit data, he demonstrated how an Light-Emitting Diodes (LED) bulb equipped with signal processing technology could stream a high-definition video to a computer and he showed that one watt LED light bulb would be enough to provide net connectivity to four computers or more.

Li-Fi Electro-Tech Revolutionalizing Oil and gas Field Operation

Production entails the fabrication at low-cost and instant available goods at high-quality. Nevertheless, with the recent manufacturing technology, most industries afford few of those qualities. Li-Fi has been spotted as the technology that can certainly replace radio frequency RF, enabling oil and gas sector to enjoy higher comprehensiveness and greater reliability in real-time monitoring of operation. Similarly, Deepika, Shaalini and Sheela cited in Ogbuji, Unyime, Ogbowu and Eze (2021) opined that in past years, constant industrial monitoring was difficult and necessary to control and monitor parameters like Pressures, frictions, voltage, gas, temperature, current as prevailing concerns during drilling processes. The authors proposed that LiFi based industrial field monitoring system that continuously measuring industrial parameters be adopted; in a way that if any abnormal condition happens, it directly sends a message to the administrator through Light fidelity communication. Small mistakes in transporting and refining petroleum products can lead to serious accidents leading to heavy environmental implications, therefore oil and gas sectors must seek resources that improves efficiency and maintain safety in other to remain profitable in her operations, hence, lifi electro-tech is poised to address these issues and transform oil and gas field operations. LiFi electro-tech system allows operators to observe the present situations of their assets or facilities; the system sends alerts when there are immediate changes in operations and performance.

According to Ramadhani and Mahardika (2018), LiFi technology consists of LED Lamp as the media transmission and photo detector as a receiver of transmitted data. Lamp driver is needed to make LED working properly. Lee, randel, breyer, and koonen (2009) and Anuj-borkute (2013) established that LED light is used for illumination only by applying a constant current. LiFi electro-tech system gives the operators a remote supervision at several locations simultaneously with improved coordinated efforts when natural disasters and other hazardous conditions tend to truncate operations. A light emitting diode lamp emits modulated visible light which acts as a data transmission route. Modulation takes place in a speedy manner that humans cannot notice it.

Typically, Ramadhani and Mahardika (2018) highlighted different modulations into Single Carrier Modulation (SCM), Multiple Carrier Modulation (MCM), and Colour Modulation. Data that are transmitted by LED are modulated into carrier signals consisting of light pulses at a shortest space of time depending on modulation design used.

Photo-detector are sometimes refers to as Photodiode, photo sensor or light-detector, these photodiodes are semiconductor devices (silicon) responsive to high energy particles and photons. On the receiver side there is a photo detector, which converts light into electric signals and gives the electric signals to the device connected to it. Singh and Bijnor (2013) examined that a transceiver is a block that acts as a transmitter and receiver consisting of LEDs to transmit the light and a photodiode to receive the light, Amplifier is embedded to strengthen the power of light received from the photodiode, the modem is used to modulate and demodulate the signal, the signal that comes from the photodiode is analog and it converts into digital in the modem. The change in temperature ultimately affects the behavior of photodiode.

OIL/ GAS FIELD OPERATION AMONG IOCs

In no distance time now, most international oil companies may perhaps not allow optical fiber cable, Wi-Fi over radiation concerns, lack of dedicated spectrum and extremely expensive nature. Ogbuji, Enyime, Ogbowu and Eze(2021) described oil and gas operation to include exploration, upstream, midstream, Refining and petrochemical facilities, whereas the authors explained that oil and gas exploration consists of prospecting, subsonic, and drilling

activities that takes place before the development of a field is finally decided. IOCs are majorly cornered with exploration and exploitation of petroleum products such as oil and gas.

Mathieson (2007) sighted that the activities in oil and gas operation are faced with emerging constraints, noting that many of these restraints are related to technological vagueness seen in offshore reserves in past years. Whereas, fast and efficient Information transmission to other locations, data aggregation from multiple sources, and data analysis, remotely located staff having access to engage with rig personnel are the Improvements telecommunications technology have added to IOCs field operation. This could be accomplished using Li-Fi electro-Tech system.

Statement Problem

It is often frustrating when the slow speed of network leads to limited connectivity and long processing hours while using wireless internet either in oil and gas facilities or supervisory control room network or having bandwidth challenges receiving feedback from remote operational areas. Ogbuji, Unyime, Ogbowu and Eze (2021) studied oil and gas industry to involve complex processes, critical operations for exploration and exploitation with manual processing and monitoring, creating a number of problems like they are not scale well, relay based systems do not provide enough data and obstruct production due to unplanned down line and environmental issues. Moreover, Mohammed, Waziri, Wajeb, Muhammad, and Quratulain (2018) revealed that the harsh and hostile industrial environment in Niger delta has pose a threat on manual monitoring tank level, pressure relief valves, equipment condition, and integrity of pipelines, detection and localization of various anomalous events like fire outbreak, blockage, corrosion and leakage occurring in different areas of oil fields.

Therefore, it's also relatable that international oil companies IOCs are faced with emerging constraints such as radio wave and unlicensed bands to meet operational parameters is associated to technological vagueness seen in offshore reserves and operation in recent time. However,. Data transmitting facilities with such ambiguity are limited in terms of memory, processing capability and speed of computation for remotely underwater operation (well-heads) leading to communication interference and performance degradation in oilfield operations. Hence, this study "Li-Fi Electro-Tech Wireless Communication for Revolutionizing Information Transmission In Oil/ Gas Field Operation among Iocs specifically examined: Transceiver Network and Modulation Network for revolutionizing information transmission in oil/gas filed operation.

METHODOLOGY

The study adopted a survey research design. The study was carried out in Niger Delta region of Nigeria. The prevailing presence of exploitation and exploration of oil and gas by international oil companies (IOCs) and local oil companies has placed a massive demand of visible light communication (Li-fi) wireless networks for revolutionizing information transmission. The population of this study consisted of all 432 supervisory control and data acquisition SCADA System personnels in oil and gas companies operating in Nigeria oil producing states. A simple random sampling technique was employed to sample SCADA personnel's of oil and gas companies in Imo State (2 personnel each from 3 companies = 6), Anambara State (2 personnel from 1 company = 2), Lagos State (2 personnel from 1 company = 2), Rivers State (2 personnel each from 3 companies = 6), Bayelsa state (2 personnel each from 3 companies = 6), Delta State (3 personnel each from 3 companies = 6) Akwa-Ibom state (4 personnel each from 4 companies = 16), Cross River State (2 personnel each from 3 companies = 6) and Ondo state (2 personnel each from 3 companies = 6). Therefore, the sample size of 56 supervisory control and data acquisition (SCADA) system personnel's was used for the study. The instrument for data collection was an unstructured focused group

online-based interview. The instrument was analyzed using thematic coding system and a simple percentage.

Results

Interview Question 1

Describe the Transceiver network behavior in transmitting information?

Extracts

Interview Extracts	**Codes**
Act as a transmitter and receiver at the same time	Transceiver Block
LED light bulbs at downlink transmitter.	LED Bulbs
Converts tiny changes in amplitude into an electrical signal-data stream	Amplifier
Streams data embedded in its beam at ultra high speeds to the photodiodes.	Photodiodes
Modem is used to modulate and demodulate the signal	Modem
Lamp to LED functions to drive current to get flickering for data transmission	Flickering for data transmission



From interview theme 1. On Transceiver network behavior in transmitting information, participants often described transceiver as acting as a transmitter and receiver at the same time. 7.14% of the participants noted “Transceiver Block” as both a transmitter and a receiver, represented with color code purple. Participants also cited a Lamp attached to LED functions to drive current to get flickering. 30.36% of participants noted “flickering for data transmission” represented with Green color code. LED Bulb at downlink to transmit light, 17.85% participants noted “LED bulbs” which is coded with color Orange, among others where the participants responses on Transceiver network behavior for Revolutionizing Information Transmission In Oil/ Gas Field Operation among Iocs

Interview Question 2

What are the Modulation Techniques in transmitting information?

Interview Extracts	Code
Amplitude shift keying ASK Technique: uses a sub-carrier index to transmit information to the receiver.	Sub-carrier index
OFDM Technique: provides multiple dimensions modulations to increase efficiency and performance.	Multiple Dimensio
ON-OFF modulation: transmits information at flicking state in an increasing or dimming level.	UsesON-OFF
Pulse-position modulation technique: encodes data using position of light pulse within a time period to support light dimming	Supports Light Dir



From interview theme 2. On Modulation Techniques in transmitting information, participants often described Amplitude Shift Keying technique as a single modulation technique. 12.5% of the participants noted "sub-carrier index" as a source of transmitting information to the receiver, represented with purple color code. Participants also cited ON-OFF modulation to be a place holder in transmitting information at increasing and dimming level. 37.5% of participants noted "ON-OFF flickering state" represented with Green color code, among others where the participants responses on Modulation Techniques for Revolutionizing Information Transmission In Oil/ Gas Field Operation among Iocs

Discussion of Findings

Findings of this study on Transceiver Network behavior for revolutionizing information transmission in oil/gas filed operation implies that transceiver block that functions as both a transmitter and a receiver consists of light emitting diode LED to transmit light and photodiode to receive the light, embedded amplifier to strengthen the light received from the photodiode, the modem to modulate and demodulate the signal. While this significant behavior of a transceiver network is imperative in building a Li-Fi electro-tech system, the threat of network or signal interference is a major concern. This finding aligns with the study of Bao, Yu, Dai, and Zhu (2015) who stated that in LiFi technology, the transmitter should be able to maintain a directional link during the transmission. The authors noted that it is because the uplink service can interfere with the downlink signal. The findings of this study on Modulation Techniques for revolutionizing information transmission in oil/gas filed operation exposed that OFDM Technique as a modulation method provides multiple dimensions modulations to increase efficiency and performance production in oil and gas field operation. This multifaceted modulation technique is a veritable tool in mitigating signal interference in information transmission. On the contrary, how does modulation support rapid flickering of LED to transmit data at a dimming state? This finding aligns with the view of Lee and Jung (2012) who assumed that while the dimming process is proportional to brightness LEDs, the area of interest is how the dimming design can fulfill user's satisfaction.

Conclusion

This paper outlined how Transceiver Network behaves and different modulation technologies for revolutionizing information transmission in oil/gas filed operation. The main idea behind Li-Fi electro-tech system is to efficiently and reliably transmit information at high speeds rate with the aid of visible light band. The medium of data transmission has quality advantage over RF waves seen in Wi-Fi, but not better in outdoor operations so to say. The twinning together of Li-Fi –Wi-Fi technologies can be deployed to realize greener and clean network signal. This paper also made emphasis on multifaceted modulation technology as the key of Li-Fi electro-tech communication.

Recommendations

Electrical and computer engineers/technologists should be consulted on building the following:

1. Faster Multi-Modulation circuit that handle rapid flicking state data transmission in low rate lighting. This multifaceted modulation will reliably on a quicker on-off state illuminate brightness for user connectivity satisfaction, especially in undersea oil and gas operation and other remote areas.
2. Out-door Li-Fi interconnected with Wi-Fi technology system that can inspect control pipelines, wellheads and gas wells, manifolds etc against, leakages, temperature variation, physical insecurity and performance degradation among IOCs .

REFERENCES

ANUJ-BORKUTE, A.P (2013). Light Fidelity-The future technology In Wireless communication. *International Journal of Scientific & Engineering Research, Volume 4(12) 153-161.*

Bao, X., Yu, G., Dai, J., and Zhu, X (2015). Li-Fi: Light fidelity-a survey. *Wirel. Networks 21(6) pp 1879–89*

Lee, s. C. J., randel, s., breyer, f., and koonen, a. M. J., (2009). "pam-dmt for intensity-modulated and direct-detection optical communication systems," *ieee photonics technology letters 21, 1749–1751*

Lee, S.J., and Jung, S.Y., (2012). A SNR analysis of the visible light channel environment for visible light communication. *APCC 2012 - 18th Asia-Pacific Conf. Commun. "Green Smart Commun. IT Innov." pp 709–12*

Mathieson, D. (2007). Forces that will shape intelligent wells development. *Journal of Petroleum Technology, 1 (8) 14-16. Doi: 10.211810807-0014-JPT*

Mohammed, T, A, Waziri, Z.K. Wajeb, G. Muhammad, K.K., Quratulain. A. (2018). Wireless sensor Network in oil and gas industry: Recent advances, taxonomy, requirements, and open challenges. *Journal of network and computer application 113 87-97*

Ogbuji, E.N., Edem, U. J.,Ogbowu, N.C., and Eze, P.N (2021). Industrial Impact of Multimedia As Monitoring Vehicle On Oil & Gas Field Operation In Niger Delta Region In Covid-19 Pandemic. *International Journal of Innovative Scientific & Engineering Technologies Research 9(4):1-12*.

Raafat. A, Simon. T, and Nizar. Z (2015). Overview of LiFi Technology. A semiar report in Higher Institute for Applied Sciences and Technology Communications Department, Syrian Arab Republic. *DOI: 10.13140/RG.2.1.1440.0080*

Ramadhani, E and Mahardika, G. P (2018). The Technology of LiFi: A Brief Introduction. *IOP Conf. Series: Materials Science and Engineering 325. 012013 online doi:10.1088/1757-899X/325/1/012013*

Singh, P.Y.P., and Bijnor, U.P., (2013). A comparative and critical technical study of the Li-Fi (A Future Communication). V / S Wi-Fi 2(4) pp 2011–3.

Weiya Zheng, Lixin Wang (2004). Electronic Technology Foundation. Higher Education Press, 2004, p. 223-253.

ASSESSMENT OF DIGITAL PEDAGOGICAL, INFORMATION AND COMMUNICATION SKILLS COMPETENCY REQUIRED BY ELECTRICAL/ELECTRONIC TECHNOLOGY LECTURERS FOR EFFECTIVE INSTRUCTIONAL IN NORTH-EAST NIGERIA'S COLLEGES OF EDUCATION (TECHNICAL)

MBAGA, Emmanuel Vandi, DAUDA, & Moses ANJILI, Tanimu
MBAGA, Emmanuel Vandi[1]
Department of Electrical Technology Education, MAUTECH, Yola
DAUDA, Moses[2]
Department of Electrical Technology Education, MAUTECH, Yola
ANJILI, Tanimu[3]
tanimuanjili@gmail.com
Department of Electrical Technology Education, MAUTECH, Yola

ABSRACT

The study seek to assess digital pedagogical, information and communication skills competency required by electrical/electronic technology lecturers for effective instructional delivery in Colleges of education (technical) in North East Nigeria. Descriptive survey research design was used for the study, while a structured questionnaire was used to assess digital pedagogical, information and communication skills competency required by electrical/electronic technology lecturers. In total, 45 Lecturers responded to the questionnaire. Two research questions and two null hypotheses were formulated to guide the study. Standard deviation and mean scores statistical measures were used to answer research questions, while the t-test was used to test the null hypothesis at 0.05 level of confidence using statistical package for social science (SPSS). The study revealed among others that digital pedagogical, information and communication skills competency such as; skills competency in making videos without software, presentation, editing pictures without software, creating online quizzes, evaluating Web contents, internet communication, and active participation in a digital environments are required by electrical/electronic technology lecturers. The study concluded that these skills competencies are much required by Electrical/electronic technology lecturers for effective instructional delivery in Colleges of Education (Technical) in North-East Nigeria. Based on the findings and conclusion of the study, it was recommended among others that: regular workshop and seminar should be organized to Electrical/electronic technology lecturers, they should be a platform in which they can share ideas and knowledge on digital skills, government should provide stable Internet facilities, smart board, internet connectivity, projectors, power supply, classroom connected to internet, Moodle software among others that is accessible by the lecturers.

Key Words: pedagogical, information and communication skill competencies

INTRODUCTION

Technological revolution in educational sector has brought about radical changes in the educational systems, which facilitate the method of instructional delivery. Teaching using technological tools is the result of the social changes that we have experienced in the last decades, however, it is only in year 2019 that we have witnessed how globalization is rapidly expanding. Indeed, the ceaseless evolution of ICT, the rapid multiplication of information, the deployment of assorted resources and digital media, their unparalleled usage, the call for educational platforms that support distance education, and the critical shift from conventional classroom instruction to emergency remote teaching in response to the COVID-19 pandemic, are vivid demonstrations of this technological revolution. In this context, digital competence has gained a strong prominence in the educational field in recent times, because the use of technology has become a daily occurrence; that is, professional development of many citizens depends largely and increasingly on an efficient and

appropriate use of technologies. In this regard, digital skills competence is one of the key skills that lecturers and students in this 21st century require (Iordache, Mariën, & Baelden, 2017).

Digital pedagogical, information and communication skills competencies refers to how a lecturers can teach a course while adhering to ideas like teaching from the know to the unknow, concrete to abstract, and simple to complex (Murkatik, Harapan and Wardiah, 2020). Lecturer's ability to plan for teaching determines his or her effectiveness in the classroom. It's important to point out that the most important resource for learning is the lecturers, with his skills, styles, and strategies. Competent is some who has been well educated and taught to teach possesses the necessary traits or talents, and can teach effectively (Miller, Ramirez & Murdock, 2017). Other skills of competent Lecturers include subject matter knowledge, pedagogy, ability processes, resourcefulness, behaviour motivation, and assessment (Kenny, Berenson, Chick, Johnson, Keegan, Read & Reid, 2017). According to Bala, Ezugu, Ali and Isah (2023), the main components of the Digital Pedagogical, information and communication skills competencies are knowledge of classroom management, knowledge of teaching methods, knowledge of classroom assessment, structure of learning objectives and the lesson process, lesson planning and evaluation and adaptability dealing with heterogeneous learning groups in the classroom

The growing concern in developing digital pedagogical, information and communication skills competency Electrical/electronic technology Lecturers can mean the integration of digital technology in to practices. The role of digital pedagogical, information and communication skills competency in education and the ability of Electrical/electronic technology Lecturers to develop their competencies accordingly have to be seen as timely and aptly. Therefore Electrical/electronic technology Lecturers should stay abreast of changing technologies and current opportunities. Electrical/electronic technology Lecturers are academic staff in colleges of education (technical) with minimum qualification of first degree second class lower division and above. They are employed to teach a range of Electrical/electronic courses such as; Electrical circuits and Electrical Measuring Instruments, Electrical and Electronics Devices, Information and Communication Technology (ICT), Electrical and Electronics Drawing, digital electronic, electrical machines and power, telecommunications among others, Electrical/electronic technology Lecturers are expected to create forum, upload courses, and assess students, post comments, and blogs among others on e-learning environment, for effective instructional delivery everybody involved both male and female need to be ready to use digital technology (Uche, Celestine, & Auwal, 2022). With the advent of digital technology, Electrical/electronic Lecturers in COE (technical) have a range of instructional delivery alternatives, and they should be ready to pass on vital skills, values, and information to students. In this era of digitalization, electrical/electronic technology lecturers must be digitally competent in order to meet the global standard of the 21st century teaching, learning and research. To accomplish this, a shift from traditional teaching, learning, and research methods to digital approach methods is necessary. This involves the use of digital technology in teaching and learning. The importance of highlighting the use and significance of digital skills in every instructional delivery context cannot be overstated. For effective teaching and learning to take place, lecturers should make use of digital technology that will allow them to teach their students through the use of computers, internet, smart boards and others digital device/tools, these can help them acquire information, creative, coordinating, calculating, concentration and cognitive skills among others, these skills, once developed by students would lead to the improvement of their status in life, development of the nation's economy, creation of self-employment, and proper utilization of human and material resources. Through the use Technology, instructional delivery is enhanced, whereby lecturers can handle large classes

conveniently using digital tools such as computer–aided gadgets, projector, and television, among others (Surajudeen & Ismail, 2018). Using digital tools for effective instructional delivery can also help lecturers avoid communication mishaps, when messages and information are shared digitally; misplaced notes and lost assignment sheets become a thing of the past which increases competency and efficiency of the work. Upon this background, this study assess pedagogical information and communication skills competencies required by electrical/electronic technology lecturers for effective instructional delivery in colleges of education (technical) in North East Nigeria

Statement of the Problem

Technological revolution demands electrical/electronic technology lecturers to acquire digital skills that would enable them to effectively teach, assess, access, evaluate, organize and communicate information electronically. This is important as it enhances teaching and learning outcomes, also it prepares students for digital work environment (Oluka & Onyebuenyi, 2023). Despite the importance of digital skills, there is still a skill gap among electrical/electronic technology lecturers in terms of software utilization, digital information and communication, digital collaboration, programming among others for teaching and learning. Teaching of electrical/electrical technology courses in COE (Technical) is faced with challenges due to inadequate technological equipment such as computers, projectors, internet facilities, smart board, among others, even where such equipment are available they are not utilized in teaching and learning, or they are not functioning (Okwelle & Allagoa, 2014), other reasons are poor basic knowledge of digital technology as most electrical/electronic technology lecturers that are exposed to basic computer knowledge lack the required digital skills that could qualify them as being digital literate and competent, also concern has been raised against the electrical/electronic technology graduates being unable to use technological equipment, which has led to a widespread about the inability of the electrical/electronic technology teachers to perform on the job, in most case blaming it on pre-service teaching received in Colleges of Education (Technical) (Taiwo & Ifeanyi, 2021). Study by (Mohammed, Aniekan, Isaac & Momoh, 2023) showed that most electrical/electronic technology lecturers lack adequate digital skills when it comes to the use of technological tools for instructional delivery, if the current method (teacher-centered) of instructional delivery is not supplemented with technological means of instructional delivery, electrical/electronic technology graduates would continue to lag behind in terms of problem-solving, innovative and analytical skills among others, this is because COE (Technical) have not instilled adequate digital skills in the students through the integration of technological facilities into the program. It is against this background, therefore, that the study intends to assess the digital skills competency required by electrical/electronic technology lecturers for effective instructional delivery in Colleges of Education (Technical). This study is considered very important especially in this era of digitalization as it will provide an in-depth understanding of the current digital skills competency required by electrical/electronic technology lecturers for effective instructional delivery in Colleges of Education (Technical) in North East Nigeria.

Purpose of the Study

The main purpose of the study is to Assess Digital Skills Competency Required by Electrical/Electronic Technology Lecturers for effective instruction in North-East Nigeria's colleges of education (technical). Specifically, the study seeks to determine the:

1. Digital pedagogical skills competencies required by electrical/electronic technology lecturers for effective instruction in North-East Nigeria's colleges of education (technical)

2. Digital information and communication skills competencies required by electrical/ electronic technology lecturers for effective instruction in North-East Nigeria's colleges of education (technical)

Research Questions

In line with the specific purpose of the study, answers to the following questions will be sought;

1. What are the digital pedagogical skills competencies required by electrical/electronic technology lecturers for effective instruction in North-East Nigeria's colleges of education (technical)?
2. What are the digital information and communication skills competencies required by electrical/electronic technology lecturers for effective instruction in North-East Nigeria's colleges of education (technical)?

METHODOLOGY

Descriptive Survey research design was adopted for the study. The area of this study was North East States Nigeria consisting of six states. These six states are; Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe states. The population of the study is 45 subjects consisting of 41 male lecturers and 4 female lecturers of electrical/electronic technology. The entire population (45 respondents) of the 6 COE (technical) was used for the study because it is not too large to handle. The instrument for data collection was structured questionnaire named "Assessment of Digital Skills Competency Required by Electrical/Electronic Technology Lecturers for Effective Instructional (ADSCREETLEI) in North-East Nigeria's Colleges of Education (Technical) designed by the researchers. The instrument was validated by three specialists and hereafter was trial tested on 5 Electrical/Electronic Technology Lecturers from federal college of education (Technical) Bitchi Kano. A reliability coefficient 0f 0.996 was obtained Cronbach Alpha Formular. Two questions were answered using mean and standard deviation, the corresponding hypotheses were tested using t-test of difference at 0.05 level of significance. The decision to consider item as agree or disagree was based on the upper limit of point 3.0 on the five point scale which is 3.50. Thus, all items with mean rating of 3.50 and above were considered as agree and below 3.50 were considered as disagree.

RESULTS

Table 1: mean rating and standard deviation of response of respondents on digital pedagogical skills competencies required by electrical/ electronic technology lecturers for effective instruction in North-East Nigeria's colleges of education (technical)

S/N	ITEMS	Nm-41		Nf-4		$\bar{X}_{ig}$	SDig	Remark
		$\bar{X}_m$	SDm	$\bar{X}_f$	SDf			
1.	Ability to state lesson objectives correctly in the three domains of learning	4.26	0.77	4.25	0.50	4.25	0.63	Required
2.	Ability to use a variety of instructional techniques to teach	4.14	0.88	4.25	0.50	4.19	0.69	Required
3.	Ability to develop appropriate instruments for assessing students' performance in the three domains of learning	4.17	0.89	3.75	0.50	3.95	0.69	Required
4.	Ability to organize learning materials logically	4.12	0.84	4.25	0.50	4.18	0.67	Required
5.	Ability to connect lessons with students life experiences	4.17	0.80	4.25	0.50	4.21	0.65	Required

6.	Ability to conclude lessons appropriately	4.09	0.80	4.50	0.57	4.29	0.68	Required
7.	Ability to engage students in activities that encourage them to think critically and construct knowledge by themselves	4.14	0.88	4.25	0.50	4.19	0.69	Required
8.	Ability to select instructional materials correctly	4.09	0.83	4.00	0.01	4.04	0.41	Required
9.	Ability to set examination questions to cover various cognitive levels	4.24	0.79	4.25	0.50	4.25	0.64	Required
10.	Ability to arrange counseling programme based assessment results	4.29	0.81	4.25	0.50	4.27	0.65	Required
11.	Ability to use various methods in motivating students to learn	4.26	0.67	4.25	0.50	4.25	0.58	Required
12.	Ability to explain difficult/abstract concepts clearly	4.29	0.74	4.50	0.57	4.39	0.65	Required
	$\bar{X}$G/SDG	**4.52**	**0.83**	**4.22**	**0.47**	**4.20**	**0.63**	**Required**

Key: $\bar{X}$m-male lecturers' mean response, $\bar{X}$f- female lecturers' mean response, SDm-male lecturers' standard deviation, SDf- male lecturers' standard deviation, $\bar{X}$ig - Item grand mean, N_m-Number of male lecturers' Nf- Number of female lecturers', $\bar{X}$G/SDG-Grand mean/Grand Standard deviation

The results presented in Table 1 showed that Electrical/Electronic Technology Lecturers accepted all the items (1 to 12) as the digital pedagogical skills competencies required by electrical/electronic technology lecturers for effective instruction in North-East Nigeria's colleges of education (technical). This is because the items have grand mean ranging between 4.09 and 4.31 which is above the cut off point of 3.50 on a five point scale.

Table 2: Mean rating and standard deviation of responses of respondents on digital information and communication skills competencies required by electrical/electronic technology lecturers for effective instruction in North-East Nigeria's colleges of education (technical)

S/N	ITEMS	Nm-41		Nf-4		$\bar{X}_{ig}$	SDig	Remark
		$\bar{X}_m$	SD_m	$\bar{X}_f$	SD_f			
13.	Ability to organize digital materials for effective instructional delivery.	4.31	0.64	4.25	0.50	4.28	0.57	Required
14.	Ability to store digital materials for effective instructional delivery.	4.21	0.68	4.25	0.50	4.23	0.59	Required
15.	Ability to format digital materials for effective instructional delivery.	4.24	0.76	4.00	0.81	4.12	0.78	Required
16.	Ability to keep digital materials safe for effective instructional delivery.	4.14	0.90	4.25	0.50	4.19	0.70	Required
17.	Ability to maintain digital content in an accessible format to ensure	4.21	0.75	4.25	0.50	4.23	0.62	Require

	effective to instructional delivery.							d
18.	Ability to search and find digital information for effective instructional delivery.	4.26	0.80	4.25	0.95	4.25	0.87	Required
19.	Ability to navigate between many online resources for effective instructional delivery.	4.19	0.74	4.25	0.95	4.22	0.84	Required
20.	Ability to sort out irrelevant information from digital materials for effective instructional delivery.	4.19	0.71	4.25	0.50	4.22	0.60	Required
21.	Ability to process digital information for effective instructional delivery.	4.19	0.67	4.00	0.00	4.09	0.22	Required
22.	Ability to comprehend digital information for effective instructional delivery.	3.95	0.77	3.75	0.50	3.85	0.63	Required
23.	Ability to evaluate digital information for effective instructional delivery.	4.09	0.88	4.00	0.81	4.04	0.84	Required
24.	Ability to critique digital information when sent and received for effective instructional delivery.	4.07	0.75	4.50	0.57	4.28	0.66	Required
25.	Ability to seek-out self-service solutions online	4.36	0.69	4.50	0.57	4.43	0.63	Required
26.	Ability to determine the benefit from self-service solutions online for effective instructional delivery.	4.34	0.69	4.50	0.57	4.42	0.63	Required
27.	Ability to make use of digital environments for effective instructional delivery.	4.19	0.74	4.50	0.57	4.34	0.65	Required
28.	Ability to express opinions in digital environments for effective instructional delivery.	4.26	0.67	4.75	0.50	4.50	0.58	Required
29.	Ability to contribute actively in digital environments for effective instructional delivery.	4.04	0.89	4.25	0.50	4.14	0.69	Required
30.	Ability to make yourself visible in digital environments for effective instructional delivery.	4.19	0.71	4.25	0.95	4.22	0.83	Required
31.	Ability to use technology for teamwork for effective instructional delivery.	4.02	0.82	4.25	0.95	4.13	0.88	Required
32.	Ability to use technology coordination processes for effective instructional delivery.	3.95	0.77	4.50	0.57	4.22	0.67	Required
33.	Ability to use technology collaboration processes for effective instructional delivery.	4.04	0.66	4.75	0.50	4.39	0.58	Required
34.	Ability to handle e-mail programme and compose email using MS	4.19	0.74	4.50	0.57	4.34	0.65	Required

	outlook, Gmail or yahoo for effective instructional delivery.							
35.	Ability to use web browsers and search effectively for effective instructional delivery.	4.24	0.73	3.75	0.50	3.99	0.61	Required
36.	Ability to set up an internet connection and connect to the internet for effective instructional delivery.	4.07	0.95	4.00	0.81	4.03	0.88	Required
37.	Ability to interact through a wide range of digital platforms for effective instructional delivery.	4.12	0.97	4.00	0.81	4.06	0.89	Required
38.	Ability to choose the best media for communicating with a specific recipient or group for effective instructional delivery.	4.14	0.72	4.25	0.50	4.19	0.61	Required
$\bar{X}$G/SDG		**4.16**	**0.76**	**4.25**	**0.61**	**4.20**	**0.68**	**Required**

Key: $\bar{X}$m-male lecturers' mean response, $\bar{X}$f- female lecturers' mean response, SDm-male lecturers' standard deviation, SDf- male lecturers' standard deviation, $\bar{X}$ig - Item grand mean, N_m-Number of male lecturers' Nf- Number of female lecturers', $\bar{X}$G/SDG-Grand mean/Grand Standard deviation

The results presented in Table 2 showed that Electrical/Electronic Technology Lecturers accepted all the items (29 to 38) as the digital information and communication skil ls competencies required by electrical/electronic technology lecturers for effective instruction in North-East Nigeria's colleges of education (technical). This is because the items have grand mean ranging between 3.93 and 4.38 which is above the cut-off point of 3.50 on a five point scale.

Table 3: Summary of t-test analysis of significant difference between the mean response of male and female lecturers on the pedagogical skills competencies required by electrical/electronic technology lecturers for effective instruction in North-East Nigeria's colleges of education (technical).

	N	$\bar{X}$	SD	MD	Df	t-value	P-value	Remark
Male	41	4.19	.775	.036		.091	.254	Upheld Ho_4
Female	4	4.22	.415					

Key: N-number of respondents, $\bar{X}$ -mean, SD-.standard deviation MD- .mean difference df- degree of freedom

The results of the paired t-test presented in Table 3 showed that, the mean response of male lecturers was 4.19 and that of the female lecturers was 4.22 with standard deviations of 0.775 and 0.415 respectively. A mean difference of 0.17 was recorded which is not statistically significant t(43) = 0.091, p > .05. The null hypothesis was therefore upheld. Hence, there is no significant difference between the mean responses of male and female lecturers on the Digital pedagogical skills competencies required by electrical/electronic

technology lecturers for effective instruction in North-East Nigeria's colleges of education (technical). This implies that electrical/electronic technology lecturers shared similar opinion in regard to the Digital pedagogical skills competencies required by electrical/electronic technology lecturers for effective instruction in North-East Nigeria's colleges of education (technical).

Table 4: summary of t-test analysis of significant difference between the mean response of male and female lecturers on the digital information and communication skills competencies required by electrical/electronic technology lecturers for effective instruction in North-East Nigeria's colleges of education (technical).

	N	$\bar{X}$	SD	MD	Df	t-value	P-value	Remark
Male	41	4.16	.729					
				.092	43	.246	.471	Upheld Ho_2
Female	4	4.25	.541					

Key: N-number of respondents, $\bar{X}$ -mean, SD-.standard deviation MD- .mean difference df- degree of freedom

The results of the paired t-test presented in table 4 showed that, the mean response of male lecturers was 4.16 and that of the female lecturers was 4.25 with standard deviations of 0.729 and 0.541 respectively. A mean difference of 0.092 was recorded which is not statistically significant $t(43) = 0.246$, $p > 0.05$. The null hypothesis was therefore upheld. Hence, there is no significant difference between the mean responses of male and female lecturers on the Digital information and communication skills competencies required by electrical/electronic technology lecturers for effective instruction in North-East Nigeria's colleges of education (technical). This implies that electrical/electronic technology lecturer shared similar opinion in regard to the digital information and communication skills competencies required by electrical/electronic technology lecturers for effective instruction in North-East Nigeria's colleges of education (technical).

FINDINGS OF THE STUDY

The study arrived at the following Findings;

1. Digital pedagogical skills competency such as; skills competency in state lesson objectives correctly in the three domains of learning, develop appropriate instruments for assessing students' performance in the three domains of learning, organizing learning materials logically among others, are required by electrical/electronic technology lecturers for effective instruction.
2. Digital information and communication skills competency such as; storage, search, critical evaluation, self-services of digital information, collaboration, internet communication, and active participation in a digital environments are required by electrical/electronic technology lecturers for effective instructional delivery, while the supporting hypothesis as in table 9 revealed that Significant difference did not exist in the mean responses of male and female lecturers on the digital information and communication skills competencies required by electrical/electronic technology lecturers for effective instruction at a 0.05 level of significance. Both male and female lecturers all agreed that they require Digital information and communication skills competency for instructional delivery.

Discussion of Findings

Findings of the study in Table 1 revealed that electrical/electronic technology lecturers required the digital pedagogical skills competency for effective instruction in North-East Nigeria's colleges of education (technical), these skills competency include ability to state lesson objectives correctly in the three domains of learning, use a variety of instructional

techniques to teach, develop appropriate instrument for assessing students' performance in three domains of learning and organize learning materials logically. Others are ability to connect lessons with students' life experiences; engage students in activities that encourage them think critically and construct knowledge by themselves; set examination questions to cover various cognitive levels (knowledge, application, and analysis, among others); arrange counseling programme based assessment result; use various methods in motivating students to learn and explain difficult/abstract concept clearly. The supporting hypothesis as in Table 3 revealed no significant difference between the mean responses of male and female electrical/electronic technology lecturers on the digital pedagogical skills competency required by electrical/electronic technology lecturers for effective instruction in North-East Nigeria's colleges of education (technical). In further support of these findings Michael, (2019) identified the ability of describing objectives, selecting materials and organizing materials logically as some of the important pedagogical competencies teachers should possess. They noted that teachers need to be competent in pedagogical knowledge and skills because it helps them to plan teaching and learning programme, to execute the interaction, manage the learning process and also make proper assessment. They emphasized that pedagogical competency is very indispensable for teachers as it facilitates effective planning of lessons, making decisions about lesson pace, explaining materials clearly, and responding to individual differences in how students learn. The findings further lend credence to the views of Mbaga, Wampana and Shanga (2017) who noted that pedagogical knowledge and skills are considered indispensable because teaching effectiveness is greatly improved when teachers display a variety of pedagogical skills in their lesson presentations.

Findings of the study in Table 2 showed that electrical/electronic lecturers require digital information and communication skills competency for effective instruction in North-East Nigeria's colleges of education (technical), this skills competencies include storage, search, critical evaluation, self-service, active participation, and collaboration. The supporting hypothesis as in Table 4 showed that there was no significant difference between the mean responses of male and female electrical/electronic technology lecturers on the digital information and communication skills competencies required by electrical/electronic technology lecturers for effective instruction in North-East Nigeria's colleges of education (technical). The findings of this study is in agreement with Mohammed, *et al* (2023), Igbinovia, Okuonghae and Adebayo (2021) who reported that there abound digital information in the internet but one needs a specific skill to enable him/her to be able search for the correct information and where to get one, also lecturers have to ensure that the medium of communication is not bridged in order for communication to flow and the messages embedded well understood this is because information and commutation has gone beyond human and human to human and machines.

Conclusion

Based on the outcome of the study, the following conclusions were drawn, digital pedagogical skills competencies which include skills competency in state lesson objectives correctly in the three domains of learning, develop appropriate instruments for assessing students' performance in the three domains of learning, organizing learning materials logically among others are required by electrical/electronic technology lecturers for effective instructional delivery for effective instruction in North-East Nigeria's colleges of education (technical). While digital information and communication, skills competencies such as;

storage, search, critical evaluation, self-services of digital information, collaboration, internet communication, and active participation in a digital environment among others.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. Electrical/electronic technology lecturers should be encouraged by concerned authorities to use digital pedagogical skills and other available pedagogical technologies during instruction.
2. Electrical/electronic technology Lecturers should endeavor to acquire digital information and communication skills such as storage, search, and critical evaluation, self-services of digital information, collaboration, internet communication, and active participation in a digital environment by themselves, since they are an integral part of instruction delivery.

REFERENCES

Bala A.A. L. C. Ezugu, Ali Dahiru & H. M. Isah (2023) Pedagogical Skills Improvement Needs of Electrical Installation and Maintenance Work Trade Teachers for Effective Teaching in Technical Colleges in Kano State

Igbinovia, M. O., Okuonghae, O., & Adebayo, J. O. (2021). Information literacy competence in curtailing fake news about the COVID-19 pandemic among undergraduates in Nigeria. Reference Services Review, 49(1), 3-18.

Iordache, C., Mariën, I. & Baelden, D. (2017). Developing digital skills and competences: A quickscan analysis of 13 digital literacy models. *Italian journal of sociology of education*, 9(1), 6–30. https://doi.org/10.14658/pupj-ijse-2017-1-2

Kenny, N., Berenson, C., Chick, N., Johnson, C., Keegan, D., Read, E., & Reid, L. (2017, October). A developmental framework for teaching expertise in postsecondary education. In Poster presented at the International Society for the Scholarship of Teaching and Learning Conference.

Mbaga Emmanuel Vandi, Quahha David Wampana and Babayo Aliju Shanga (2017). Assessment of Technical Skills Competency Needs of Electrical Installation and Maintenance Work Trade Teachers in Skills Acquisition Centre of Yobe State. *Journal of Education and Practice*, 17(8), 102-110.

Michael, Ofonmbuk Isaac (2019) technical teachers' competency needs for effective teaching of basic technology in junior secondary schools in cross river state *published Ph.D Thesis, Nnamdi Azikiwe University*, Awka.

Miller, A. D., Ramirez, E. M., & Murdock, T. B. (2017). The influence of teachers' self-efficacy on perceptions: Perceived teacher competence and respect and student effort and achievement. Teaching and Teacher Education, 64, 260-269.

Mohammed, B. Aniekan, E. A., Isaac, J. I., Momoh, A., (2023). Digital technological competencies required by teachers of electrical/electronic technology education in tertiary institutions in north-east Nigeria, *vunoklang multidisciplinary journal of science and technology education*

Murkatik, K., Harapan, E., & Wardiah, D. (2020). The influence of professional and pedagogic competence on teacher's performance. Journal of Social Work and Science Education, 1(1), 58- 69.

Okwelle, P. C., & Allagoa, F. O. N., (2014). Enhancing teachers competence in the use of instructional materials in electronics education in senior secondary schools in Nigeria. research on humanities and social sciences. 4 (28), 20-27

Oluka, S. N., & Onyebuenyi, P. N., (2023). Skills required for effective utilization of solar energy for sustainable self-employment of electrical/electronic technology education graduates in Enugu urban. international scholars *journal of arts, humanities and social sciences*, 5(3), 234-240

Surajudeen, R. A., & Ismail, O. (2018). E-Teaching competencies for capacity-building of lecturers for effective delivery of vocational oriented courses in the universities. https://www.researchgate.net/publication/325042686

Taiwo O. S., & Ifeanyi B. O., (2021). Electrical/electronic technology education teachers attitude, engagement, and disposition towards actual usage of Mobile learning in higher institutions. *Educ Inf Technol*, 1023–1042 (2021). https://doi.org/10.1007/s10639-020-10297-y Volume 26, pages 1023–1042, (2021)

Uche D. A., Celestine, U. N., & Auwal S., (2022). Assessment of e-learning readiness of lecturers and students in federal colleges of education in North East, Nigeria *International Journal of Curriculum and Instruction 14(1) (2022) p455-472*

Leveraging AI-Powered Simulation Tools to Enhance Practical Competence in Building Technology and Electrical/Electronics Technology TVET Programs in Nigeria

Onatere-Ubrurhe, Joyce Ogheneruona[1]
Department of Technology Education, Alvan Ikoku Federal University of Education, Owerri, Nigeria
joyce.onatere-ubrurhe@alvanikoku.edu.ng

Abstract

This study investigates the integration and impact of Artificial Intelligence (AI)-powered simulation tools in enhancing practical competence in Building Technology and Electrical/Electronics Technology Technical Vocational Education and Training (TVET) programs in Nigeria. Despite global success in adopting AI-based educational technologies like Virtual Reality (VR) and Augmented Reality (AR), Nigerian TVET institutions face systemic challenges limiting implementation. Using a descriptive survey design, data were collected from 289 respondents, including educators, students, and workshop technologists. Findings revealed that only 29.8% of respondents reported access to AI-simulation tools, and even among these, usage was inconsistent, with a mean frequency of 2.99 on a 5-point scale. However, students who used the tools reported improved understanding, confidence, and practical competence, with mean scores ranging from 3.60 to 3.98. Major barriers identified included high cost, inadequate infrastructure, and insufficient staff training. These findings align with global literature, confirming the potential of AI-powered simulation tools to bridge theory-practice gaps and foster experiential learning in technical education. The study recommends investments in digital infrastructure, educator training, and policy reforms to facilitate effective integration of simulation tools. It concludes that while adoption is currently limited, AI simulations offer a transformative opportunity to modernize Nigerian TVET and enhance graduate employability in the 21st-century workforce.

Keywords: AI-powered simulation tools, practical competence, TVET, Nigeria, virtual reality integration.

Introduction

Technical Vocational Education and Training (TVET) plays a vital role in equipping learners with the practical and occupational skills needed for employment and sustainable development (UNESCO, 2022). In Nigeria, TVET is essential to bridge the skills gap in sectors like construction and electrical/electronics technology, where hands-on competence is crucial for economic and infrastructural growth (Eno *et al.,* 2025). Despite this importance, most Nigerian TVET institutions still face significant challenges in delivering practical training due to limited infrastructure, obsolete equipment, and overcrowded workshops (Abosede & Olujobi, 2024).

Recent advancements in educational technology, particularly Artificial Intelligence (AI)-powered simulation tools, offer innovative solutions to these challenges. AI-driven platforms such as virtual labs, virtual reality (VR) and augmented reality (AR) environments enable learners to practice and master technical skills in immersive, risk-free environments that replicate real-world conditions. These technologies can also adapt learning experiences to individual needs, improving retention and competence (Decker & Sumanasekara, 2025; Febri *et al.,* 2025).

In developed countries, AI-based simulations have been integrated successfully into TVET programs to improve learner engagement, self-efficacy, and hands-on performance (Zhan & Nurfaradilla, 2025; Long *et al.,* 2025). However, in Nigeria, the adoption of such innovations in TVET is still in its infancy, especially in disciplines like Building Technology and Electrical/Electronics Technology. There is therefore a need to explore how these tools can be

effectively leveraged to overcome current barriers in technical training and to improve the quality of graduates in these vital sectors (Onatere-Ubrurhe *et al.,* 2025).

TVET programs in Nigeria are designed to produce skilled professionals capable of meeting the country's technical and industrial needs. However, the persistent lack of modern training facilities, coupled with outdated pedagogical approaches, has hindered the development of practical competence among students. Many graduates from TVET programs in Building Technology and Electrical/Electronics lack the proficiency required to operate effectively in modern workplaces.

Conventional training methods are often constrained by cost, safety concerns, and limited access to physical tools and materials. As a result, students graduate without adequate exposure to real-world challenges. AI-powered simulation tools such as, VR-based construction sites and virtual circuit design labs present an opportunity to bridge this gap. Yet, their implementation and impact on practical skill development in Nigerian TVET programs remain underexplored. Hence, the main aim of this study is to assess how AI-powered simulation tools can enhance practical competence in Building Technology and Electrical/Electronics Technology TVET programs in Nigeria.

Literature Review

Conceptualizing Technical Vocational Education and Training (TVET)

Technical Vocational Education and Training (TVET) encompasses educational programs that are deliberately structured to develop practical skills and competencies relevant to specific trades or occupations. In the Nigerian context, TVET plays a crucial role in addressing youth unemployment and fostering sustainable economic growth through skill development. The National Board for Technical Education (NBTE) has consistently emphasized practical competence as a core outcome of TVET programs (Ajeniweni, et al 2024).

Despite its potential, TVET in Nigeria faces several challenges including poor infrastructure, inadequate training equipment, outdated curricula, and limited access to modern teaching technologies. These issues have led to a skills gap between graduates of TVET institutions and the actual demands of modern industries, especially in construction and electrical sectors that are rapidly evolving due to digitization and automation (Edidiong *et al.,* 2024; UNESCO, 2023).

Modern pedagogical strategies now advocate for competency-based education and industry-driven training models. Integration of emerging technologies such as Artificial Intelligence (AI), simulation, and immersive virtual learning platforms has been proposed as a viable solution to enhance the effectiveness of TVET delivery and bridge the theory-practice divide (Edidiong *et al.,* 2024).

AI-Powered Simulation Tools in Education

Artificial Intelligence (AI) simulation tools are designed to mimic real-life processes, allowing learners to interact with virtual environments to develop skills in a controlled, repeatable, and scalable manner. Examples include virtual reality (VR), augmented reality (AR), digital twin simulations, and intelligent tutoring systems (Iqbal *et al.,* 2024). These technologies provide learners with an experiential learning environment where theoretical concepts are translated into practical knowledge.

The use of AI-powered simulations in education has seen rapid growth, particularly in fields that require hands-on practice but face limitations due to cost, safety, or access. In medical education, for example, VR simulations are widely used to teach surgical procedures. Similarly, in engineering and technical education, virtual labs have emerged as a viable alternative or supplement to physical labs (Long *et al.,* 2025; Wahyudi *et al.,* 2023).

Studies show that learners trained with simulation tools often outperform those who rely solely on traditional instruction methods. Simulations offer adaptive learning experiences

where students can repeat tasks, receive instant feedback, and explore complex systems without fear of failure or physical harm (Febri et al 2025; Iqbal *et al.,* 2024).

Simulation-Based Learning in Building Technology and Electrical/Electronics Technology

Building Technology and Electrical/Electronics Technology are disciplines that demand high levels of accuracy, safety consciousness, and hands-on problem-solving capabilities. These competencies are essential not only for academic performance but also for real-world application in industries such as construction, manufacturing, telecommunications, and energy. Traditional workshop-based instruction, while effective to an extent, often falls short due to limitations in access to resources, safety concerns, and cost of materials (Onatere-Ubrurhe *et al.,* 2025).

In this context, AI-powered simulations are proving to be transformative tools in technical vocational education. These technologies can replicate real-world construction sites, architectural planning processes, electrical circuits, and wiring systems with a high degree of fidelity. For instance, learners can interact with digital models of construction equipment, structural frameworks, and electrical boards, providing them with a risk-free, repeatable environment to build competence. These virtual environments are not only cost-effective but also scalable, allowing multiple students to engage simultaneously without the logistical burden of physical materials (Onatere-Ubrurhe *et al.,* 2025).

Virtual labs such as Labster, Simutech, and Multisim now offer specialized modules in topics like circuit analysis, motor control systems, HVAC systems, and structural load testing. These platforms enable learners to visualize abstract concepts, simulate physical responses in real-time, and engage in interactive problem-solving scenarios. According to Onatere-Ubrurhe et al. (2025), students who used building technology simulation platforms demonstrated improved comprehension of complex structural design procedures. Their study noted a measurable increase in readiness for industrial attachment programs among students exposed to simulation-based training, suggesting that virtual experiences can effectively bridge the gap between theory and practice.

In the field of Electrical/Electronics Technology, simulations serve as powerful substitutes for physical circuit assemblies, allowing students to build, test, and troubleshoot circuits virtually. This digital approach is particularly beneficial in settings where access to expensive, delicate, or high-voltage equipment is limited. AI-based simulators can detect learner input, provide real-time feedback, and adapt difficulty levels according to learner progress, offering a personalized learning experience that traditional workshops cannot match. VR-based electrical simulators can enhance students' fault diagnosis skills and better retention compared to those taught via conventional workshop demonstrations (Asham *et al.,* 2023).

Moreover, simulation tools allow for the replication of dangerous, rare, or emergency scenarios, which are usually difficult or impossible to create in a typical classroom or lab environment due to safety or financial constraints. These may include electrical overloads, arc faults, or structural failures. Exposing students to such virtual scenarios expands their problem-solving repertoire and enhances their preparedness for unpredictable conditions in real-life jobs. This kind of experiential learning is invaluable in technical fields where rapid decision-making under pressure is often required (Scorgie *et al.,* 2024).

Beyond technical skill acquisition, simulation-based learning also contributes to the development of soft skills such as collaboration, time management, and critical thinking, especially when learners engage in team-based virtual tasks. As educational institutions in Nigeria and globally aim to align TVET outcomes with industry needs, the integration of simulation technologies into curricula represents a strategic pathway to improving both the quality and relevance of technical education (Onatere-Ubrurhe *et al.,* 2025).

Integration of AI Tools into TVET Institutions

The integration of AI-powered tools in Nigerian Technical Vocational Education and Training (TVET) institutions is still emerging. While pilot programs exist in some private technical institutions, most public colleges face challenges including lack of funding, insufficient power supply, poor internet infrastructure, and low digital literacy among instructors (Ohwoeke & Chukwuka, 2023; Animashaun *et al.*, 2024).

Despite these barriers, national education strategies have begun to emphasize the importance of EdTech integration. The Federal Ministry of Education, through the Nigeria Education Sector Strategic Plan (NESSP), advocates for digital transformation in teaching and learning processes, particularly in science and technology education (Hezron, 2024). However, implementation at the institutional level remains inconsistent (Dakuku, 2024).

Studies indicate that where simulations have been adopted, the transition requires more than technological acquisition it also involves training of educators, curriculum redesign, and change management (Yulin & Danso, 2025). Teachers' reluctance or lack of confidence in using new tools has been cited as a major limitation (Ndeokwelu, 2023). Therefore, effective integration depends on both technical infrastructure and human capacity development (Ajayi & Smith, 2021)

Impact of AI Simulation Tools on Practical Competence

Various studies affirm the positive impact of AI-based simulations on practical competence development. Simulation-based instruction enhances spatial visualization, critical thinking, and procedural mastery key competencies in both building and electrical trades (Yang *et al.*, 2024). In addition, students exposed to VR/AR simulations tend to be more engaged, motivated, and confident in performing real-life tasks (Khan *et al.*, 2019; Liu, 2025).

Research has found that learners trained using AI-assisted circuit simulations scored significantly higher in post-lab practical tests than those using textbooks alone. Similarly, research in building construction labs showed increased precision in structural drawings and improved safety compliance when simulations were used during practical training (Yang *et al.*, 2024).

Moreover, simulations facilitate individualized learning. AI-driven environments can adapt to learners' skill levels, offering guidance or increased complexity based on performance. This personalized experience enhances mastery and reduces anxiety often associated with technical assessments (Kumbo *et al.*, 2024).

Challenges in Implementing Simulation Technologies in Nigerian TVET

Despite the benefits, implementing AI simulation tools in Nigeria's TVET institutions faces several systemic challenges. These include:

- **Infrastructure Deficit**: A significant number of TVET institutions in Nigeria operate without stable electricity and lack reliable internet connectivity, both of which are essential for the deployment of Virtual Reality (VR) and Augmented Reality (AR) tools. This infrastructural inadequacy is more pronounced in rural areas, where institutions struggle with inadequate bandwidth and slow internet speeds, making it difficult to access cloud-based AI educational platforms and real-time data analytics. Moreover, the persistent issue of unstable electricity supply forces many institutions to rely on costly alternatives such as generators and inverters, further straining their resources (Onatere-Ubrurhe *et al.*, 2025, Kennedy *et al.*, 2022).
- **High Cost of Tools**: The financial burden associated with acquiring and maintaining commercial simulation platforms is a significant barrier for public TVET institutions. These platforms often require high-end hardware and software, which are priced beyond the reach of many colleges operating on limited budgets. The lack of resources contributes to the graduation of under-skilled professionals, undermining the goal of

technical education to equip students for self-reliance and employment (Onatere-Ubrurhe *et al.,* 2025; Kennedy *et al.,* 2022).

- **Staff Training Gaps**: The successful adoption of AI simulation tools is contingent upon the digital literacy and technical proficiency of educators. However, many technical instructors in Nigerian TVET institutions lack exposure and training in emerging technologies, which remains a major bottleneck in successful adoption. Studies have revealed that TVET educators require a range of digital skills to implement digital learning effectively, and the absence of these skills hampers the integration of technology into teaching practices (Onatere-Ubrurhe *et al.,* 2025; Kennedy *et al.,* 2022).
- **Curriculum Misalignment**: Existing curricula often do not provide for digital alternatives to practical training, leading to a mismatch between teaching tools and assessment frameworks (Onatere-Ubrurhe *et al.,* 2025; Kennedy *et al.,* 2022).

These challenges point to the need for systemic reform in policy, funding, and human capacity to support the successful adoption of AI-driven tools for skill development in Nigeria.

Research Methods

Population and sample

The target population for this study comprises TVET Educators, Students, and Workshop Technologist specializing in Building Technology and Electrical/Electronics Technology TVET programs in Nigeria. This population was chosen due to their direct involvement in teaching, learning, and managing the relevant technical programs and simulation environments. The purposive sampling technique was used to select participants and the total number of respondents is 289 (Etikan *et al.,* 2016). Table 1 contains the Respondents profile.

DEMOGRAPHICS	**DISTRIBUTIONS**	
ROLE	Educator	98 (33.9%)
	Student	145 (50.2%)
	Workshop Technologist	46 (15.9%)
AREA OF SPECIALIZATION	Building Technology	124 (42.9%)
	Electrical/Electronics Technology	165 (57.1%)
Total Number of Respondents = 289		

Table 1. Respondents profile

Data Collection Methods

Data collection involved both primary and secondary sources to ensure a robust analysis.

Primary Data

Primary data was collected through survey method. A structured questionnaire was distributed to TVET Educators, Students, and Workshop Technologist specializing in Building Technology and Electrical/Electronics Technology to capture their perceptions and challenges related to AI-powered simulation tools. The questionnaire was distributed online. The study targeted 300 respondents. However, 289 valid responses were obtained, representing a 96.3% response rate, which is considered highly acceptable for statistical analysis.

Secondary Data

Secondary data was sourced from academic journals, institutional reports, and industry publications to provide a contextual background and support the primary data findings.

Ethical Consideration

This study adhered to ethical research principles to ensure the protection and rights of participants. Informed consent was obtained by briefing participants on the study's purpose

and ensuring their voluntary agreement to participate. Confidentiality was maintained by keeping all responses private and preventing the disclosure of any identifying information.

Data Analysis methods

The study employed descriptive statistical method (frequencies, percentages, mean, and standard deviation) to analyze the data, IBM SPSS Statistics 26 was used for data processing, ensuring the accuracy and reliability of the statistical outputs (IBM Corp., 2019).

Data Presentation and Interpretation

The analyzed data have been presented in the following tables.

Availability and Accessibility of AI-Powered Simulation Tools

Question	Yes	No
Are AI-powered Simulation tools such as Virtual reality and Augmented Reality, available in your institution? (This question is for Educators, Students and Workshop Technologists)	86 (29.8%)	203 (70.2%)

Table 2. Availability and Accessibility of AI-Powered Simulation Tools

Interpretation

The data presented in table 2 reveals that the availability of AI-powered simulation tools, such as Virtual Reality (VR) and Augmented Reality (AR) in institutions offering Building Technology and Electrical/Electronics Technology TVET programs in Nigeria is significantly limited. Out of the total 289 respondents, only 86 individuals (29.8%) reported that such tools are available in their institutions, while a substantial majority of 203 respondents (70.2%) indicated that these tools are not available. This suggests that although AI-powered simulation technologies are recognized as transformative for enhancing practical competence, their adoption and integration into Nigerian TVET institutions remain critically low. The widespread unavailability highlights a major gap in access to modern, immersive training technologies.

Utilization of AI Simulation Platforms

Question	Very Frequently (5)	Frequently (4)	Occasionally (3)	Rarely (2)	Never (1)	Mean	Standard Deviation
If Yes, how frequently are AI-powered simulation tools used for practical training in your institution? (This question is for Educators, Students and Workshop Technologists).	7 (8.1%)	20 (23.3%)	33 (38.4%)	18 (20.9 %)	8 (9.3%)	2.99	1.10

Table 3. Utilization of AI Simulation Platforms

Interpretation

The data presented in table 3 shows that among the 86 respondents who confirmed the availability of AI-powered simulation tools in their institutions, the frequency of usage for practical training remains moderate. Specifically, only 7 respondents (8.1%) reported using these tools very "frequently", while 20 (23.3%) use them frequently, and the highest proportion, 33 respondents (38.4%), indicated occasional use. Additionally, 18 respondents (20.9%) stated that they "rarely" use the tools, and 8 (9.3%) admitted to never using them despite their availability. The mean score of 2.99 on a 5-point scale suggests an overall

moderate level of utilization, hovering around the "occasionally" mark. The standard deviation of 1.10 indicates a relatively wide variation in usage patterns, implying inconsistency across institutions. This variation may reflect disparities in institutional capacity, user training, technical support, or curriculum integration. Overall, the results point to an underutilization of available AI simulation tools, highlighting the need for stronger institutional commitment, training, and infrastructure to ensure more consistent and effective use of these technologies in TVET practical training.

Perceived Impact on Practical Competence

This section is for only those students that have access to AI-Simulation tools for Practical training.

Please indicate your level of agreement with the following statements using the 5-point Likert scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

No.	Statement	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)	Mean	Standard Deviation
1	Simulation tools have improved my understanding of practical concepts.	12 (26.7%)	24 (53.3%)	6 (13.3%)	2 (4.4%)	1 (2.2%)	3.98	0.88
2	I perform better in real-life tasks after practicing with simulations.	11 (24.4%)	21 (46.7%)	8 (17.8%)	3 (6.7%)	2 (4.4%)	3.80	1.00
3	I am more confident in handling workshop equipment due to virtual training.	9 (20.0%)	19 (42.2%)	10 (22.2%)	4 (8.9%)	3 (6.7%)	3.60	1.06
4	I retain knowledge better through simulation-based learning.	11 (24.4%)	23 (51.1%)	7 (15.6%)	3 (6.7%)	1 (2.2%)	3.89	0.94
5	The use of AI tools has enhanced my overall practical competence.	10 (22.2%)	25 (55.6%)	6 (13.3%)	2 (4.4%)	2 (4.4%)	3.87	0.92

Table 4. Perceived Impact on Practical Competence

The data presented in table 4 reflects students' perceptions of the impact of AI-powered simulation tools on their practical competence in Building Technology and Electrical/Electronics Technology TVET programs. Overall, the responses indicate a strong positive perception. For instance, the statement "Simulation tools have improved my understanding of practical concepts" recorded the highest mean score of 3.98 with 80% of students agreeing or strongly agreeing, suggesting that these tools significantly enhance conceptual clarity. Similarly, students affirmed improved knowledge retention (mean = 3.89) and overall practical competence (mean =3.87), with over 75% of respondents supporting these views. Performance in real-life tasks (mean = 3.80) and confidence in handling workshop equipment (mean = 3.60) also received positive ratings, though with slightly more neutral and disagreeing responses, reflecting some variability in personal experience or tool effectiveness. The standard deviations, ranging from 0.88 to 1.06, indicate moderate

variability in student responses. Overall, the findings suggest that AI-powered simulation tools have a broadly positive impact on students' practical learning outcomes, though the full benefit may depend on factors such as usage frequency, tool quality, and instructional support.

Challenges in Implementation

This section is for Educators, Students and Workshop Technologists.

Please indicate your level of agreement with the following statements using the 5-point Likert scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

No.	Statement	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)	Mean	Standard Deviation
1	The cost of acquiring simulation tools is a major barrier.	102 (35.3%)	119 (41.2%)	40 (13.8%)	21 (7.3%)	7 (2.4%)	3.99	1.02
2	There is insufficient training for instructors on using AI tools.	80 (27.7%)	122 (42.2%)	55 (19%)	23 (8%)	9 (3.1%)	3.83	1.03
3	Most institutions lack the infrastructure to support simulation technology.	96 (33.3%)	125 (43.3%)	42 (14.5%)	18 (6.2%)	8 (2.8%)	3.98	1.00
4	There is a general resistance to adopting new technologies.	74 (25.6%)	118 (40.8%)	59 (20.4%)	28 (9.7%)	10 (3.5%)	3.75	1.05
5	Simulation tools are difficult to maintain and update.	67 (23.2%)	113 (39.1%)	67 (23.2%)	31 (10.7%)	11 (3.8%)	3.68	1.07

Table 5. Challenges affecting the implementation of AI-powered simulation tools

Interpretation

The data presented in table 5 highlights several significant challenges affecting the implementation of AI-powered simulation tools in Building Technology and Electrical/Electronics Technology TVET programs across Nigerian institutions. Foremost among these is the "high cost of acquiring simulation tools," which recorded the highest mean score of 3.99, with 76.5% of respondents agreeing or strongly agreeing that it is a major barrier. This is closely followed by "lack of infrastructure" (mean = 3.98) and "insufficient instructor training" (mean = 3.83), both of which also had over 70% agreement, indicating that financial constraints and institutional capacity limitations are major obstacles. Additionally, "resistance to adopting new technologies" (mean = 3.75) and the "difficulty of maintaining and updating simulation tools" (mean = 3.68) were recognized as moderate challenges, with notable portions of respondents either neutral or in agreement. The standard deviations, ranging from 1.00 to 1.07, suggest a moderate spread in opinions, reflecting some variability in institutional contexts. Overall, the findings reveal that while there is recognition of the potential benefits of AI-powered simulation tools, their widespread adoption is hindered by systemic challenges such as cost, inadequate infrastructure, limited technical know-how, and change resistance issues that must be addressed to fully harness these tools for enhancing practical competence in Nigerian TVET programs.

Discussion of Findings

The findings reveal several critical insights into the current state and potential of AI-driven simulation technologies in Nigerian TVET. Firstly, only 29.8% of the respondents confirmed

the availability of AI-powered simulation tools in their institutions, indicating low adoption. This finding aligns with Kennedy et al. (2022), who also reported limited access and utilization of digital tools in Nigerian technical education, affirming the accuracy of the current study's observation. Among those with access, usage remains inconsistent, with a mean score of 2.99 (on a 5-point scale), suggesting moderate use. This pattern reflects Long et al. (2025), who observed that despite high potential, VR tools in vocational training are underutilized due to infrastructural and institutional barriers. On the perceived impact, students who used AI tools reported high positive influence on understanding, competence, and retention (mean scores ranging from 3.60 to 3.98). This is strongly supported by Yang et al. (2024), who found that simulation-enhanced training significantly improved learners' spatial and procedural skills, and by Febri et al. (2025), who noted that AI simulations improve learner confidence and performance. The study also reported systemic challenges such as high cost, lack of infrastructure, and inadequate instructor training, all scoring above 3.68. These challenges are echoed by Onatere-Ubrurhe et al. (2025) and Kennedy et al. (2022), who both emphasized that cost and lack of digital readiness hinder widespread adoption in Nigeria. The current study's findings also agree with Edidiong et al. (2024), who advocated for AI integration but stressed the need for educator support and infrastructure development. Notably, resistance to technology was also cited, resonating with Yulin and Danso (2025), who found that institutional unpreparedness and lack of pedagogical readiness often stall EdTech implementation. In summary, the study's findings are largely supported by current literature, affirming the potential of AI-powered simulation tools to enhance TVET delivery, while also highlighting critical barriers that must be addressed through policy reform, infrastructure investment, and human capacity development.

Significance of the study

The significance of this study lies in its timely exploration of how Artificial Intelligence (AI)-powered simulation tools can address longstanding challenges in Nigeria's Technical Vocational Education and Training (TVET), particularly in Building Technology and Electrical/Electronics Technology programs. By empirically evaluating the availability, usage, perceived impact, and implementation challenges of these tools, the study provides valuable insights for educators, policymakers, and institutional leaders seeking to modernize technical education and bridge the gap between theoretical instruction and practical competence. It highlights how simulation technologies can enhance learning outcomes, improve student confidence, and promote safety and efficiency in skill acquisition, offering scalable, cost-effective alternatives to traditional workshop training. Furthermore, the study contributes to the growing body of knowledge on EdTech integration in developing countries, positioning AI simulations as a strategic solution to boost employability, foster innovation, and align TVET outputs with the demands of the modern labor market.

Conclusion

This study concludes that AI-powered simulation tools hold significant promise in enhancing practical competence in Building Technology and Electrical/Electronics Technology TVET programs in Nigeria. Despite the transformative potential of technologies like Virtual Reality (VR) and Augmented Reality (AR) in offering immersive, hands-on learning experiences, their availability and usage in Nigerian TVET institutions remain critically limited. The data revealed that less than one-third of respondents have access to such tools, and even among those with access, usage is inconsistent and predominantly occasional. Nevertheless, the perceived impact among students who have used these tools is overwhelmingly positive, with high ratings in areas such as conceptual understanding, knowledge retention, confidence in handling equipment, and overall practical competence. These findings affirm the effectiveness of AI-simulation tools in bridging the gap between theoretical instruction and real-world application. However, systemic challenges such as high acquisition and maintenance costs,

insufficient infrastructure and lack of educator training continue to hinder broader adoption. Therefore, for AI-powered simulation tools to be effectively mainstreamed in Nigerian TVET, there is a need for comprehensive reforms involving infrastructural investments, educator capacity building, curriculum redesign, and policy-level support. The integration of these tools is not merely a technological upgrade but a strategic imperative to modernize technical education, improve learner outcomes, and better align TVET graduates with the demands of the 21st-century workforce.

Limitations

The scope of this research was constrained by time and resource limitations, which may affect the depth and breadth of data collection and analysis.

Recommendations

Based on the findings, the following recommendations have been proposed.

1. **Invest in Digital Infrastructure and Power Supply**
   Government and institutional stakeholders should prioritize upgrading digital infrastructure, such as stable electricity, high-speed internet, and modern computer systems, to enable the effective use of AI-powered simulation tools in TVET institutions.
2. **Subsidize Access to Simulation Tools**
   Public-private partnerships should be leveraged to reduce the cost burden of acquiring, maintaining, and updating commercial simulation platforms, ensuring that even underfunded institutions can adopt these technologies.
3. **Strengthen Educator Capacity through Training**
   Continuous professional development programs must be implemented to equip TVET educators and workshop technologists with the digital skills needed to effectively integrate simulation technologies into teaching.
4. **Integrate Simulation into TVET Curriculum**
   National and institutional curriculum bodies should revise TVET curricula to formally incorporate AI-powered simulation as a core component of practical training and assessment strategies.
5. **Promote Adoption Through Awareness and Change Management**
   Institutions should run sensitization programs to reduce resistance to technology adoption, fostering positive attitudes and readiness among both staff and students toward simulation-based learning.
6. **Establish Monitoring and Evaluation Systems**
   A structured framework should be introduced to regularly evaluate the impact of AI simulations on learning outcomes, graduate employability, and institutional performance, guiding continuous improvement and policy development.

Further research

While this study has made significant contributions, it also opens avenues for further inquiry such as;

- Exploring student attitudes and motivation when using AI-powered simulations in remote or hybrid learning settings.
- Evaluating how gender or socioeconomic status influences access to and benefits derived from simulation-based training in TVET institutions.
- Conducting longitudinal studies to evaluate the long-term impact of simulation tools on graduate employability and workplace performance.
- Exploring the cost-benefit implications of AI-driven simulations across different technical specializations in TVET.

References

Abosede. O.B. & Olujobi. O.A. (2024). Incorporating Multimedia Technology into TVET Curricula: Strategies for Fostering Innovation in Nigeria. *Ilaro Journal of Science and Technology (IJST)*, 4, 1-5.

Ajayi, E.A., & Smith, A. (2021). *Effect of cloud-based learning management system on the learning management system implementation process: Faculty and student perspectives.* Proceedings of the 2019 ACM SIGUCCS Annual Conference, 176-179. https://doi.org/10.48550/arXiv.2102.10522

Ajeniweni, P.O., Bamgbowu, S.A., Obasi, I.K., Akinola, B.T. & Nudegbesi, A.M. (2024). The Role Of Vocational Education In Promoting Economic Growth In Nigeria. *Journal Of Economics and Environmental Education*, 8(1), 23-41. Animashaun, E. S., Familoni,

B. T., & Onyebuchi, N. C. (2024). Strategic project management for digital transformations in public sector education systems. *International Journal of Management & Entrepreneurship Research*, 6(6), 1813-1823.

Asham Y., Bakr, M.H. & Emadi, A. (2023). Applications of Augmented and Virtual Reality in Electrical Engineering Education: A Review. *IEEE Access*, 11, 134717- 134738.

Dakuku, P. (2024). Tunji Alausa and Nigeria's grand education strategy. *Premium Times*. https://www.premiumtimesng.com/opinion/749657-tunji-alausa-and-nigerias-grand-education-strategy-by-dakuku-peterside.html?tztc=1

Deckker, D. & Sumanasekara, S. (2025). AI In Vocational and Technical Education: Revolutionizing Skill-Based Learning. *EPRA International Journal of Multidisciplinary Research (IJMR)*, 11(3), 9-23.

Edidiong, I.S., Mfon, O.E. & Ikanaobong, M.A. (2024). Exploring AI-Driven Adaptive Learning Systems for Personalized Education in Nigerian TVET Institutions to Enhance Student Engagement and Skill Acquisition Outcomes. *World Journal of Innovation and Modern Technology*, 8(5), 188-198.

Eno, O.J., Ntiedo, A.U. & Emmanuel, S.E. (2025). TVET Quality Assurance in Nigeria Towards Achieving SDG 2030: Ending Poverty Through Skill Development. *Research Journal of Pure Science and Technology*, 8(2), 77-89.

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistics*, 5(1), 1–4.

Febri, P., Aprilla, F., Agariadne, D.S., Dinda, K.L., Welli, A., Utari, A.G., Muhammad, R., Santiago, C-C., Deniz, K., & Juan Luis, C.G. (2025). Harnessing artificial intelligence to revolutionize vocational education: Emerging trends, challenges, and contributions to SDGs 2030, *Social Sciences & Humanities Open*, 11, 101401.

Hezron, R. (2024). National Education Sector Strategic Plan (NESSP) 2023-2027 – Teachers Updates - https://teachersupdates.news/cs-machogu-unveils-national-education-sector-strategic-plan-nessp-2023-2027-key-pillars/

IBM Corp. (2019). *IBM SPSS Statistics for Windows, Version 26.0*. Armonk, NY: IBM Corp.

Iqbal, M., Khan, N.U & Imran, M. (2024). The Role of Artificial Intelligence (AI) In Transforming Educational Practices: Opportunities, Challenges, and Implications. *Qlantic Journal of Social Sciences and Humanities*. 5. 348-359.

Kennedy, G. W., Ekong, M. O., & Okorie, M.N. (2022). Digital Technological Tools for Technical Vocational Education and Training Interactive Learning: Availability and Utilization in Nigerian Universities. *Rivers State University Journal of Education (RSUJOE)*, 25(2), 85-95.

Liu, L. (2025). Enhancing educational training and learning outcomes through a hybrid experience created by integrating augmented reality and virtual reality technologies.

Journal of Computational Methods in Sciences and Engineering. 25(3), 2310-2321. doi:10.1177/14727978241312994

Long, Y., Zhang, X. & Zeng, X. (2025). Application and effect analysis of virtual reality technology in vocational education practical training. *Educ Inf Technol* 30, 9755–9786. https://doi.org/10.1007/s10639-024-13197-7

Khan, J., Johnston, K. & Ophoff, J. (2019). The Impact of an Augmented Reality Application on Learning Motivation of Students. *Advances in Human-Computer Interaction*, https://doi.org/10.1155/2019/7208494

Kumbo, L.I., Nkwera, V.S., Mero, R.F., Sikumbili, R.M. & Mushi, M.L. (2024). Enhancing Competency-Based Education Training in Dar Es Salaam, Tanzania, With Augmented Reality and Virtual Reality Technologies. *The Cradle of Knowledge: African Journal of Educational and Social Science Research*, 12(4), 2617-7315.

Ndeokwelu, E. (2023). Leveraging digital transformation in the Nigerian education sector. *Medium*. https://medium.com/@echendeokwelu/leveraging-digital-transformation-in-the-nigerian-education-sector-f92dcff0015b

Onatere-Ubrurhe J.O., Chinyio E. & Georgakis P. (2025). Enhancing Building Technology Education through the Integration of Virtual Reality, *International Journal of Education, Learning and Development*, 13(1), 65-84.

Owhoeke, N.G. & Chukwuka, G.K. (2023). Designing Smart and Innovative Learning Education System in Nigerian Tertiary Institutions. *Innovation.* 4(2), 14-24. https://doi.org/10.11648/j.innov.20230402.11

Scorgie, D., Feng, Z., Paes, D., Parisi, F., Yiu, T.W. & R. Lovreglio (2024). Virtual reality for safety training: A systematic literature review and meta-analysis, *Safety Science*, 171, 106372.

UNESCO (2022). Transforming technical and vocational education and training for successful and just transitions: UNESCO strategy 2022-2029. DOI: https://doi.org/10.54675/EUDU5854

Wahyudi, M. N. A., Budiyanto, C. W., Widiastuti, I., Hatta, P. & Bakar, M. S. (2023). Understanding Virtual Laboratories in Engineering Education: A Systematic Literature Review. *International Journal of Pedagogy and Teacher Education*, 7(2), 102-118. https://dx.doi.org/10.20961/ijpte.v7i2.85271

Yang, C., Zhang, J., Hu, Y., Yang, X., Chen, M., Shan, M. & Li, L. (2024). The impact of virtual reality on practical skills for students in science and engineering education: a meta-analysis *International Journal of STEM Education*, 11(28), 1-15. https://doi.org/10.1186/s40594-024-00487-2

Yulin, N., & Danso, S. D. (2025). Assessing pedagogical readiness for digital innovation: A mixed-methods study. *arXiv*. https://arxiv.org/abs/2502.15781

Zhan Z. & Nurfaradilla, M.N. (2025). Immersive Virtual Reality in Vocational School: A Systematic Literature Review. *International Journal of Academic Research in Progressive Education and Development*, 14(1), 1294-1309.

Digital Skills Requirement of Electrical / Electronics Technology Graduates for Economic Diversification in the 21st Century Educational Landscape in Rivers State.

Prof. P. C. Okwelle
National Commission for Colleges of Education, Abuja, Nigeria
E-mail: pcokwelle@gmil.com
G.S.M.: 08023311199
Agwi Vincent I. A. Ph.D
Department of Industrial and Technology Education
Alvan Ikoku Federal University of Education, Owerri, Imo State
E-mail: agwivincent@gmil.com
G.S.M: 08037769765
And
Law-Obi Fidelia Nwanneka
Department of Industrial and Technology Education
Alvan Ikoku Federal University of Education, Owerri, Imo State
E-mail: fidelia.Law-obi@alvanikoku.edu.ng
G.S.M: 08137708813

Abstract
The study focused on digital skills requirement of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State. Three research questions and three hypotheses guided the study. The population of the study was 94 (comprising 43 lecturers and 51 PG students). The instrument for data collection was a structured questionnaire titled "Digital Skills Requirement for Electrical/Electronics Technology Education Graduates" Questionnaire (DSRETEG). Mean and standard deviation were used to answer the research questions while t-test was used to test the hypotheses at 0.05 level of significance. Findings of the study revealed that information and communication skills are digital skills that are required for economic diversification in Rivers State, specialized use of ICT mediated learning skills are required by electrical/electronics technology graduates for economic diversification in Rivers State, ICTs programme support skills are also required by electrical/electronics graduates for economic diversification in Rivers State. Based on these findings, recommendations were made that ICT centres in all the tertiary institutions in Rivers State should be well equipped by the government with modern internet facilities; training sections should always be organized for all TVET students on the effective use of digital skills during the period of their training in the school.

Keywords: Digital Skills, Graduates, Economic Diversification, Educational Landscape.

Introduction

Education anywhere is a process of training designed to give knowledge, develop skills and abilities that could lead to the development of mental alertness and the right attitude to life. According to Howe (2023) Education is widely acknowledged as an instrument per excellence for achieving socio-economic growth and national development. This implies that if education is adequately inculcated in human-kind individuals would meaningfully help in achieving socio-economic growth and development in any nation of the world as presently observed in most developed countries such as Japan, China, India, America among others. In essence education remains the single factor that guarantees both individual growth and community development. Thus, if an individual acquires skill and the right attitude, and realistically apply the skills and right attitude for the benefit of his or her society, it means that

education has helped to transform the individual for better livelihood. Technical and Vocational Education and Training (TVET) is one of the educational programme that can help to achieve the goal of socio-economic growth and development in the 21st century educational landscape.

Technical and Vocational Education and Training (TVET) refers to education and training programme given to the learners in order to help them acquire skills, knowledge and attitude required in the world of work and necessary for employment in an occupation. TVET as defined by UNESCO and adopted by the Federal Republic of Nigeria in her National Policy on Education (2013) is a comprehensive term referring to those aspect of the educational process involving in addition to general education, the study of technologist and related science and the acquisition of practical skill, attitude, understanding and knowledge relating to occupation in various sectors of economic and social life. TVET focuses on hand-on-real-work applications, preparing learners for direct entry into the work force. According to Anaele (2023) TVET encompasses a diverse range of fields; including but not limited to Agriculture, Health care, Home Economics and Hospitality Management, Building Trades, Mechanical Trades, Wood Work Trades, Automobile Trades and Electrical Electronics trades.

Electrical/Electronics technology trade is a technical course that focuses on the principles and applications of electrical and electronics system. According to Kenz (2022) Electrical/electronics technology is a comprehensive course that covers the fundamentals of electrical and electronics circuit devices and system. During training period in the school students usually learn about the design, development, testing and maintenance of electrical and electronic system, including electrical circuits, electronic devices, microcontrollers, electrical machines and control system. Career opportunities for graduates who majored in electrical/electronics technology according to Smith (2024) include, electrical engineer, electronics engineer, control system engineer, electrical technician and electronics engineer. In Nigeria Universities, Polytechnics, Technical Colleges of Education, Monotechnics and Technical colleges are institutions where learners are equipped with the right skills, knowledge, understanding and attitude needed in the world of work. Technology education graduates have distinctive role to play not only do they need to have sound knowledge in their field of study they also need to be expert in their field of study and also have practical and up-to-date vocational experts relevant to the work place (Morgan, 2022). Therefore, TVET is a powerful tool for economic diversification only when TVET students are equipped with not just sills in manipulating tools and machine but also digital skills to meet the fast changing technological world of work.

Digital skills according to Brown and Sheriff (2022) is the abilities and knowledge required to effectively use digital technologies, such as computers, smart phones and internet to achieve personal social and professional goals. National Policy on Information and Communication Technology (ICT) in School Education cited in James and Audu (2023) posited that digital skills are the perspective of the new educational training with a clear objective of educating and preparing students, allowing them to appropriate themselves of new ICT knowledge and tools that serve to include them within the educational system. According to Hosfal and Sana (2022) the incorporation of new technological structures facilitate the incorporation of new approaches to teaching and evaluating students with ICT for observing the progress they have made that is these competences develop planning and organizational skills in education which aids the construction of new knowledge, using technologies as tools in new scenariors. The digital skills of the 21st century drive the competitiveness and innovation capacity of organization (Sarka, ange2023) Brody and Clifford (2021) asserted that digital skills revolve

around the ability to search for information, the ability to express oneself in different programming language and the capacity for social interaction, integrating new technologies.

Digital skills is the basic understanding of how to interact with a computer, how to interact with applications on the computer, how to do what you want in real time (Kufor, 2021). In the same vein, Markson (2023) stated that digital skills can be defined as the ability to locate, organize, understand, evaluate, and create information using digital technology. According to Hillton and Stephen (2021) digital learning encompasses many different facts, tools and applications to support and empower both teachers' and students', including online courses blended or hybrid learning, or digital content and resources. Digital literacy is the ability to understand and use digital technologies effectively for everyday tasks. According to Donald (2024) digital skills encompass a range of competences which include, basic digital skills, Information and Communication Technology (ICT) skills, digital literacy, data skills, creative digital skills, technical digital skills. In TVET educational programme such as electrical/electronics technology, digital skills are essential for students to acquire in today's digital economy for socio-economic growth and development and as well as economic diversification.

Economic diversification refers to the process of reducing a country's or region's dependence on or a single industry or sector by developing and promoting other sectors to achieve a more balanced and resilient economy. To achieve this goal Uwakwe (2022) stated that technology education students undergoing training in technical training institutions needed to be equipped with the right knowledge, understanding, attitude and digital skills needed in the world of work. All over the globe the increase use of ICTs in TVET has resulted in a major paradigm shift from a total dependence on the objective paradigm to a growing adherence to the cognitive and constructive paradigm. For example the use of ICTs in distance education has resulted in a pedagogy, which is constructivist, collaborative and interactive (Mills and Harison, 2021).

Several studies such as (Lang and Kress, 2021; Burnell, 2022; Kendel, 2023; Seaborn, 2024) have shown that there are ICT skills required by students undergoing training in technology education related programmes in institutions of learning. According to Cannon (2023) Information and Communication Technology skill need of computer education students for software development such as proper mouse handling, good typing skills, programming, system skill, error detection skill among others. Sahama (2021) stated that vocational education graduates require spreadsheet skills, word processing and electronic office operation skills, auto-card skill in order to be able to face industrial activities in the world of work upon their graduation from school. Information and Communication Technology mediated learning is guided by Activity-base Reflection and socially Oriented Learning. Theories-Activity Base Theory places emphases activity exploring the achievement. According to Talbort (2019) ICT-mediated learning encourages learning by doing; it enhances the learning environment and required students to develop critical thinking research and evaluation skills. Taylor and Jones (2024) highlight the following as skills that every technology education graduates should posses which is guaranteed to increase overall digital know-how from simply branding yourself online to learning basic coding such as the ability to set up a W-Fi network, the ability to back up to the cloud, basic photo exhibiting video editing, Google docs and Microsoft office, HTML and basic coding.

In addition, according to Tias and Sampson (2025) research has proven that ICT-mediated learning can be used to teach problem based learning. This can be done by making use of real

world data, through the use of visualizations, simulations, infrastructure and virtual environment. Grandvil (2023) noted that a problem can be segmented to enable learners to visually observe the operation through ICT – mediated learning. In order to resolve conflict, ICT-mediated learning has made it possible to communicate with experts using tools such as e-mail, skyee video-conferencing. Willcock (2024) emphasized that students requires online learning skills, which involves gaining of knowledge through internet, holding discussion class, sending e-mail, receiving assignment from their teachers and gaining access to their result after examinations. According to Alann and Duffy (2024) ICT literacy skills can be used by students to obtain information on assignment given by their teachers, study for their assignment during course work and be able to detect plagiarism during research work.

Statement of the Problem

The adoption and integration of ICTs into the teaching and learning environment offers more opportunities for both teachers and students in educational programmes to work better in a globalized digital age (Lugard, 2024). In Nigeria the situation is supposed to be the same as the world is going digital. Therefore, there is need for Technical and vocational Education and Training students offering programme in any of the technology related courses to meet up with the goal of socio-economic growth and development through TVET programme. There are concept s in TVET that can only be imparted to the students by the teacher digitally for better understanding. This can only be achieved when TVET students move with the current trends in technological advancement which is reflected in the changing patterns of TVET curriculum. Researchers, educators, policymaker and organizations alike are beginning to recognize that choosing the digital gap is essential to preparing the nation's educational sector especially TVET for a successful future. This is in line with Maxwell and Santos (2023) that the rapid pace of technological change makes fixing it more urgent than ever. Hence, it is now clear that there is need to equip TVET students with the right digital skills for economic diversification in the 21st century educational landscape in Rivers State.

Purpose of the Study

The study sought to determine digital skills requirement of electrical/electronics technology education graduations for economic diversification in the 21st century educational landscape in Rivers State. Specifically, the study was conducted to:

1. Determine Information and Communication skills requirement of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State.
2. Determine specialized use of ICT mediated learning skills requirement of electrical /electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers state.
3. Determine ICT literacy skills requirement of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State.

Research Questions

The following research questions guided the study:

1. What are the Information and Communication Skills requirement of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State?
2. What are the specialized use of ICT mediated learning skills requirement of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers state?

3. What are the ICT literacy Skills requirements of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State?

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance"

1. There is no significant difference between the mean responses of lecturers and postgraduate students on specialized use of ICT mediated learning skills requirement of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State.
2. There is no significant difference between the mean responses of lecturers and postgraduate students on ICT skills requirement of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State.
3. There is no significant difference between the mean responses of lecturers and postgraduate students on ICT literacy skills requirement of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State.

Methodology

The study adopted a descriptive survey research design. According to Gall, Gall and Bong cited in Agwi and Nnaemeka (2025) descriptive survey research design is aimed at collecting data or describing in a systematic manner the characteristic feature or fact about a given population. The study was carried out in Rivers State. The population of the study consisted of ninety four (94) respondents (comprising 43 Lecturer and 51 Postgraduate students) in the two tertiary institutions in Rivers State that offer programmes in Technology Education as at 2024/2025 academic session. The study was a census as the entire population was studied. This is in consonance with Maduabum as cited in Igwe and Eke (2024) who stated that a survey in which the entire population is studied is referred to a census. The choice of census is due to the relatively small size of the population.

The instrument for data collection was the structures questionnaire titled "Digital Skills Requirement for Electrical/Electronics Technology Education Graduates Questionnaire (DSREETEGQ)". The instrument was face and content validated by three experts in Technology Education Department, Rivers State Univesity, Port Harcourt. The instrument was structured on 4-point rating scale of Strongly Agreed (SA), Agreed (A), Disagreed (D), and Strongly Disagreed (SD). A corresponding numerical value of 4,3,2 and 1 was assigned to the response options for each item. Cronbach Alpha reliability technique was used to determine the internl consistently of the items of the questionnaire. The rehabilitee obtained was 0.85. A total of 94 copies of the instrument were administered to the respondents directly by the researchers with the help of five researches assistant.

The total number of the instrument retrieved after two weeks was 93 and was used for data analysis. The data collected from the respondents were analyzed using mean and standard deviation. The means scores were used to answer the research questions and t-test statistic was used to test the null hypotheses at 0.05 level of significance. In order to determine the acceptance or rejection level of each of the items in relation to research questions 1 to 3 a decision rule based on real limit of number was used. Any item whose mean is 2.50 above was regarded as agreed while any item whose weighted mean is below 2.50 was regarded as disagreed. Standard deviation values were used to determine the homogeneity or orderwise in among the respondents. The decision for hypotheses was that if the calculated value of t (cal.)

is less than the critical value of t (crit.) accept the null hypotheses, but if the calculated value of t (cal.) is greater than the critical value of t (crit.) reject the null hypotheses.

Results

The results of the study were presented in Tables 1 – 6 in line with the research questions and hypotheses.

Research Question 1: What are the Information and Communication skills requirement of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State?

Table 1: Mean Rating and Standing Deviation on ICT Skills Requirement of Students for Economic Diversification.

S/N	ITEMS	TVET Lecturers N = 43			PG Students N= 50		
		$\bar{x}$	SD	Remark	$\bar{x}$	SD	Remark
1.	Ability to use Interactive television.	2.65	0.71	Agreed	2.72	0.82	Agreed
2.	Ability to use ICTs for learning in TVET.	2.60	0.69	Agreed	2.68	0.71	Agreed
3.	Ability to use technology to search for information during assignment.	2.71	0.73	Agreed	2.82	0.79	Agreed
4.	Ability to use Technology as a complement to instruction.	2.82	0.78	Agreed	2.68	0.72	Agreed
5.	Ability to use Technology as on instructional tool.	2.65	0.72	Agreed	2.71	0.75	Agreed
6.	Ability to use Internet/Web-Based Learning.	2.74	0.80	Agreed	2.80	0.84	Agreed
7.	Ability to use Wireless Technologies.	2.69	0.71	Agreed	3.00	0.86	Agreed
8.	Ability to use Audio/Video conferencing.	2.53	0.65	Agreed	2.62	0.69	Agreed
9.	Ability to use Audio graphics.	2.60	0.69	Agreed	2.73	0.73	Agreed
10.	Ability to use Technology as receiving mechanism during teaching and learning.	2.57	0.68	Agreed	2.71	0.76	Agreed
	Average Grand Mean /SD	**2.66**	**0.72**		**2.75**	**0.77**	

Source: Field Survey, 2025

Data in Table 1 revealed that TVET Lecturers had a mean range of 2.53 to 2.83 and standard deviation range of 0.65 to 0.80 while the Postgraduate students had a mean of 2.62 to 3.00 and standard deviation range of 0.69 to 0.86. The closeness of the standard deviation shows that the respondents are close in their responses. The mean showed that the respondents agreed that Information and Communication skills are required for economic diversification in the 21st century educational landscape in Rivers State.

Research Question 2: What are the specialized use of ICT mediated learning skills requirement of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State?

Table 2: Mean Rating and Standard Deviation on Specialized use of ICT Mediated Learning Skills Requirement of Students for Economic Diversification.

S/N	ITEMS	TVET Lecturers N = 43			PG Students N= 50		
		$\overline{x}$	SD	Remark	$\overline{x}$	SD	Remark
11.	Ability to use ICTs to learn electrical/electronics technology.	2.53	0.75	Agreed	2.63	0.82	Agreed
12.	Ability to use ICTs to detect fault during practical.	2.64	0.78	Agreed	2.57	0.81	Agreed
13.	Ability to use ICTs to learn practical skills.	2.71	0.82	Agreed	2.79	0.83	Agreed
14.	Ability to use ICTs during workshop training in electrical/electronics.	2.74	0.83	Agreed	3.00	0.81	Agreed
15.	Ability to use ICTs for informal skills development.	2.69	0.74	Agreed	3.02	0.89	Agreed
16.	Ability to use ICTs for prior learning Assessment and Recognition.	2.58	0.77	Agreed	2.66	0.75	Agreed
17.	Ability to use ICTs for Virtual Internship.	2.55	0.76	Agreed	2.84	0.81	Agreed
18.	Ability to use ICTs to learn how to draw electric circuit.	2.63	0.75	Agreed	2.79	0.85	Agreed
19.	Ability to use ICTs to learn electric drawing.	2.61	0.72	Agreed	2.83	0.87	Agreed
20.	Ability to use ICTs to learn how to install electric points.	2.67	0.75	Agreed	2.79	0.85	Agreed
	Average Grand Mean/SD	2.64	0.77		2.79	0.84	

Source: Field Survey, 2025

Data in Table 2 revealed that TVET Lecturers had a mean range of 2.53 to 2.74 and standard deviation range of 0.75 to 0.83 while the Postgraduate students had a mean range of 2.57 to 3.02 and standard deviation range of 0.81 to 0.89. The standard deviation shows that the respondents are close in their responses. The mean showed that the respondents agreed that specialized use of ICT-mediated learning skills are required by electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State.

Research Question 3: What are the ICT literacy skills requirements of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State?

Table 3: Mean Rating and Standard Deviation on ICT Literacy Skills Requirements of Students for Economic Diversification.

S/N	ITEMS	TVET Lecturers N = 43			PG Students N= 50		
		$\overline{x}$	SD	Remark	$\overline{x}$	SD	Remark
21.	Using ICTs for students learning and development in TVET.	2.78	0.79	Agreed	2.95	0.83	Agreed
22.	Programme planning	2.63	0.71	Agreed	2.74	0.78	Agreed

	development.						
23.	Undertaking of Assignment	2.75	0.76	Agreed	2.84	0.79	Agreed
24.	Browsing for Assignment	2.54	0.70	Agreed	2.91	0.80	Agreed
25.	Browsing of information for research work.	2.59	0.73	Agreed	2.83	0.77	Agreed
26.	Individual learning.	2.71	0.72	Agreed	2.94	0.83	Agreed
27.	Practical project executive.	2.58	0.71	Agreed	2.68	0.71	Agreed
28.	Learning execution.	2.67	0.70	Agreed	2.82	0.75	Agreed
	Average Grand Mean/SD	**2.66**	**0.73**		**2.84**	**0.78**	

Survey: Field Survey, 2025

Data in Table 3 revealed that TVET Lecturers had a mean range of 2.54 to 2.78 and standard deviation range of 0.70 to 0.79 while the Postgraduate students had a mean range of 2.74 to 2.95 and standard deviation range of 0.78 to 0.83. the closeness of the standard deviation shows that the respondents agreed that ICT literacy skills are required by electrical/electronics technology education graduates for electronic diversification in the 21st century educational landscape in Rivers State.

Hypothesis 1

There is no significant difference between the mean responses of Lecturers and Postgraduate students on ICT skills requirement of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State.

Table 4: t-Test Result on ICT skills Required by Students for Economic Diversification.

Groups	N	X	SD	DF	t-cal.	t-crit.	Decision
TVET Lecturers	43	2.66	0.72				
				91	0.04	1.96	Accepted
PG Students	50	2.75	0.77				

Data in Table 4 revealed that 43 TVET Lecturers had a mean rating of 2.66 (SD = 0.72) and the 50 PG Students had a mean rating of 2.75 (SD 0.77) yielding a calculated t-value of 0.04. With the calculated t-value of 0.04 less than the critical t-value (1.96) at df = 91 and 0.05 level of significance, it is an indication that there is no significant difference between the mean responses of TVET Lecturers and Postgraduate students on ICT skills requirement of students for economic diversification in the 21st century educational landscape in Rivers State. The first null hypothesis was therefore accepted.

Hypothesis 2

There is no significant difference between the mean responses of Lecturers and Postgraduate students on specialized use of ICT mediated learning skills requirement of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State.

Table 5: t-Test Result on Specialized use of ICT Mediated Learning skills Required by Student for Economic Diversification.

Groups	N	X	SD	DF	t-cal.	t-crit.	Decision
TVET Lecturers	43	2.64	0.77				
				91	0.07	1.96	Accepted
PG Students	50	2.79	0.84				

Date in Table 5 revealed that 43 TVET Lecturers had a mean rating of 2.64 (SD = 0.77) and the 50 PG Students had a mean rating of 2.79 (SD = 0.84) yielding a calculated t-value of 0.07 with the calculated t-value of (0.07) less than the critical t-value (1.96) at df = 91 and 0.05 level of significance, it is an indication that there is no significant difference between the mean responses of TVET Lecturers and Postgraduate students on specialized use of ICT mediated learning skills requirement of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State. The second null hypothesis was therefore accepted.

Hypothesis 3
There is no significant difference between the mean responses of Lecturers and Postgraduates students on ICT literacy skills requirement of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State.

Table 6: t-Test Result on ICT Literacy skills Required by Students for Economic Diversification.

Groups	N	X	SD	DF	t-cal.	t-crit.	Decision
TVET Lecturers	43	2.66	0.73				
				91	0.08	1.96	Accepted
PG Students	50	2.84	0.78				

Data in Table 6 revealed that 43 TVET Lecturers had a mean rating of 2.66 (SD = 0.73) and the 50 PG Students had a mean rating of 2.84 (SD = 0.78) yielding a calculated t-value of 0.08. with the calculated t-value of (0.08) less than the critical t-value (1.96) at df = 91 and 0.05 level of significance, it is an indication that there is no significant different between the mean responses of TVET Lecturers and Postgraduates Students on ICT literacy skills requirement of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in River State. The third null hypothesis was therefore accepted.

Discussion of Findings
The results as presented in Table 1 above revealed that information and communication skills are required for economic diversification in the 21st century educational landscape in Rivers State. Findings of the study is in agreement with Cannon (2023) who identified the skill need of computer education students for software development such as proper mouse handling, good typing skills, programming, system skill, error detection skill among others. More so, the findings of the study is also in agreement with the opinion of Sahama (2021) who found that vocational technology graduates requires spreadsheet skills, world processing and electronic office operation skills, auto-CAD skill in order to be able to face industrial activities in the world of work upon their graduation from school.

From Table 2, the finding indicated that specialized use of ICT-mediated learning skills are required of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State. Findings of this study is in line with Taylor and Jones (2024) who highlighted a short list of fundamental skills that every technology education graduate should poses which is guaranteed to increase overall digital know-how from simply branding yourself online to learning basic coding such as the ability

to set up a Wi-Fi network, the ability to back up to the cloud, basic photo editing, basic video editing, Google docs and Microsoft office, HTME and basic coding.

The findings as presented in Table 3 revealed that ICT literacy skills are required by electrical/electronics technology graduates for economic diversification in the 21st century educational landscape in Rivers State. Findings of the study is in agreement with Alanu and Dutty (2024) who stated that ICT literacy skills can be used by students to obtain information when they are given assignment by their teachers, study for their assignment during course work and be able to detect plagiarism during research work. The findings of the study supports Willook (2020) who emphasized that students required online learning skills, which involves, gaining of knowledge through internet, holding discussion class, sending e-mail, receiving assignment from their teachers and gaining access to their result after examination.

The result of the 3 hypotheses tested showed that all the 3 hypotheses were not rejected. These further shows in the opinions of the respondents that there were no divergent opinion on the raised issues in this research bothering on digital skills requirement of electrical/electronics technology education graduates for economic diversification in the 21st century educational landscape in Rivers State.

Conclusion

Information and Communication Skill, specialized use of ICT –mediated learning skills, ICTs programme support skills and ICT literacy skills are skills required by technology education graduates for economic diversification in the 21st century educational landscape in Rivers State. Thus, there is an urgent need for technology education students to acquire online learning skills which involves gaining of knowledge through internet, holding discussion class, sending e-mails, and assessing information from the internet for assignment.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. Training sections should always be organized for all technology education students undergoing training in schools on effective use of digital skills in the classrooms.
2. Technology education students should be encouraged by concerned authorities to use the skills and other available pedagogical technologies during the period of teaching and learning of practical before field experience as this will reduce much emphasis on theories rather than practical as most technology education courses are vocational and technologically oriented in nature.
3. Government should ensure that internet facilities are connected in schools where students are undergoing training in technical related areas for easy assess to internet network.

References

Agwi, V. I. & Nnaemeka, A. M. (2025). Perceived level of skills in winding of electrical machines operation for self-employment among students of Technical Colleges in Rivers State. Manuscript submitted for publication.

Alanu, F. T & Duffy, S. (2024). Information and communication skills required by vocational teachers for effective lesson delivery. *Journal of Technology Education* 5(1), 10-15

Anaele, E. A. O (2023). Technical and Vocational Education and training (TVET): A roadmap for meeting youth migration in Nigeria. A keynote address delivered at the Annual conference at the Faculty of Vocational and Technology education. Ignatius Ajuru University of Education, Rumuolumini Port Harcourt on 7th – 9th December

Brono, C. A & Sheriff, H. E. (2021). Computer education competencies in higher education: Challenges to teacher. Retrieved 4th February, 2025 from *http//www.ed.org*

Brody, E & Clifford, U. L. (2021). Digital education and technical students: Teacher preparation for sustainable classroom development. Retrieved 10th February, 2025 from *http//www.edu.org*

Cannon, T. O. (2023). The role of ICT in improving the excellence of education. retrieved 6th January, 2025 from *http//www.edu.org*

Donald, S. E. (2024). ICT application in technical education programme in Ghana, proceeding of the International Conference of VTET Research and Network 23-24-June.

Grandvil, F. E (2023). ICT implementation among Malaysian schools, GIS, Obstacles and opportunities. Retrieved 6th January, 2025 from *http//procedures//information.org*

Hilton, G. A & Stephen, B. N. (2021). Digital skills urgently needed to bridge digital literacy gap. Retrieved 3rd March, 2025 from *http//www.digital.com/digital- skills-teaching-in-school-needs-radical think.*

Howe, C. E (2023). Technical and Vocational Education and Training (TVET): A useful means of achieving socio-economic growth and development in Zambia. *Journal of Academic excellence.* 10(1), 100-110

Hosfal, C. O. & Sana, M. T (2022). Incorporation of new technology system for effective teaching and learning of science related subjects in secondary schools: Issues and challenges. Retrieved 9th February, 2025 from *http//www.edu.org.*

Igwe, E. N. & Eke, B. O (2024). Supervisory skills need for optimum performance of technology education students in industrial work experience scheme in Imo State. *Journal of Education in Developing Areas*. 11(1), 60-75.

James, E. S & Audu, O. N (2023). Integrating ICT into teaching-learning practices: Promise, challenges and future direction of higher educational institutes. *Journal of Nigeria Vocational Association.* 19(2) 30-45.

Kandel, C. M. (2023). The relevance of computer graphic skills in TVET. *Journal of Technology Education.* 8(1), 50-60.

Kenz, M. B (2022). *A hand book of electrical/electronics technology practical operations*. London: Max Publishing Company Ltd.

Kufor, A. G. E. (2021). Ghana's digital literacy problem. Retrieved *http//www.dor.org//100-202001*.

Lang, N. T & Kress, L. O. (2021). Computing education competence in higher education: Challenges for teachers. Retrieved 12 March, 2025 from *http//www.ICT.edu.org*.

Lugard, F.T (2024). Digital skills teaching in school needs radical rethink. Retrieved 7th January, 2025 from *http//www.comp.com/2011/digital-skills-teacing*.

Maxwell, E. K & Santos, C. F. (2023). The rapid pale of technological change through ICT in higher education in America. Retrieved 8TH March, 2025 from *http//www.digital-teaching //100625.edu.org.*

Mchson, V. A (2022). Digital citizenship internet society and participation. Retrieved 13th February, 2025 from *http//www.school.com//doc/5547016//digital-citizenship.edu.org.*

Mills, F. G & Harris, N. K. (2021). Integration of information and communication technology into science education curriculum in India. Retrieved 9th January, 2025 from *http//www.ICT.edu.org.*

Morgan, W.T (2022). Practical skill need of Automobile Technology Education graduates for self-reliant. *Journal of Education in Developing Areas*. 10(1), 90-105

Sarka, M. N. (2023). Digital skills needs of technology education students for socio-economic growth in Brazil in the 21st century educational reform. *American Journal of vocational education.* 15(1) 80-95

Sahana, U. A. (2021). Digital skills required by technology education students for effective practical operations. *Journal of Academic Excellence.* 13 (1), 50 -65.

Seaborn, U. A. (2024). Digital skills every 21st century science teachers should have. Retrieved 4th March, 2025 from *http//www.weducationtechnology.com/200/20/skill.org*.

Smith, E. I (2024). Career opportunities for electrical/electronics technology graduates in the world of work. *European Journal of Educational Research*. 16(1), 30-45.

Talbort, C. L (2019). ICT-mediated learning experience required by science education students in Lagos State. Retrieved 2nd March, 2025 from *http//www.edu.org.*

Taylor, A. S. & Tores, G. T (2024). Skills that every technology education graduates should possess to guaranty increase in overall digital knowledge. Retrieved 8th March, 2025 from *http//www.digital skills.edu.org.*

Tias, M. N. & Sampson, U. N. (2025). Digital skills for American economy. Retrieved 4th February, 2025 from *http//www.digitalskill-need.of-the-American. Economy*. PdA.

Uwakwe, L. E. (2022). Integrating Information and Communication Technology into science Education Curriculum for Improving Digital Skills Competence of Science Education Students in Imo State. *Journal of Education in Developing Areas*. 15(1), 40-55.

Willcork, K. O. (2020). Online learning skills required by vocation education students for job creation in Rivers State. *Journal of Vocational and Technology Education*. 10(1), 80-95

Integrating Artificial Intelligence Digital Skills and Intelligent Systems in Electrical/Electronic Trades in Technical Colleges in Rivers State

Tambari Mtormabari DEEBOM (PhD)

Department of Vocational and Technology Education
Faculty of Education, Rivers State University Port Harcourt
Email: tambari.deebom@ust.edu.ng (+2347034909959)
&
Charity Bubelebara Okardi
Department of Electrical/Electronic Technology
Isasac Jasper Boro College of Education, Yenegoa Bayelssa State
charityokardi@gail.com

Abstract
The study examines the integration of artificial intelligence digital skills and intelligent systems in Electrical /Electronic trades in Technical Colleges in Rivers State. Four research questions were answered to guide the study. The study employs the descriptive research survey design. The population of the study was 147 respondents consist of 133 students and 14 teachers in Electrical/Electronic trades subjects. Due this small population, there was no sampling and hence it was a census study. The instrument for data collection was a self-structure questionnaire tagged "Integrating Artificial Intelligence Digital Skills and Intelligent Systems Questionnaire" which was design after modified 4-point rating scale. The instrument was validated and a reliability coefficient of 0.84 was established using Pearson Product Moment Correlation (PPMC). Data collected were analyse using mean with standard deviation. The study found that human resources (teachers) are less competent and that material resources are inadequate for the integration of artificial intelligence digital skills and intelligent systems in Electrical/Electronic trades subjects in Technical Colleges in Rivers State. Based on the findings of the study, it was recommended among others that government should organize training to enhance teachers' competence on AI and intelligent systems since the teachers are less competent on its utilization.

Keywords: Integration, Artificial Intelligence, Digital Skills, Intelligent Systems and Electrical/Electronic Trades

Introduction
To prepare students for a workforce driven by technology, Rivers State's technical colleges must incorporate digital skills, intelligent systems, and artificial intelligence (AI) into electrical and electronic trades. This can be accomplished by integrating AI into teaching, learning, and evaluation through interactive simulations, personalized learning, and cutting-edge research tools. It can also be accomplished by making sure faculty members receive the necessary training and by redesigning curricula to meet industry standards. In order to prepare students for the modern workforce, Technical Colleges in Rivers State must incorporate artificial intelligence (AI), digital skills, and intelligent systems into their electrical and electronic trades. This integration entails developing digital literacy and computational thinking abilities while integrating AI ideas like machine learning and natural language processing into curricula. AI has been described by Nwosu, Ekoh-Nweke and Zion-Ngoka (2024) and Nie (2020) as technical and scientific field devoted to the engineered system that generates outputs like forecast, content, and decisions for a given set of human-defined objectives.

Unprecedented technological developments in the twenty-first century are drastically altering economies and industries around the globe. The emerging field of artificial intelligence (AI), the widespread impact of digital technologies, and the growing complexity of intelligent systems are at the vanguard of this change. These developments are not limited to high-tech industries; they are gradually affecting traditional trades as well, necessitating a fundamental reassessment of practices, skills, and - most importantly - the educational systems that train the workforce of the future.

Modern infrastructure is based on the electrical and electronic trades, which power communication networks, homes, and businesses. For the installation, upkeep, repair, and innovation of electrical and electronic systems, qualified technicians and engineers in these domains are crucial. However, technical colleges' traditional teaching methods frequently fall behind the real world's quick technological advancement. As the world tends to adopt digital technologies and skills, graduates who lack proficiency in these areas run the risk of becoming unprepared for the demands of the modern workplace as industries increasingly adopt AI-driven tools, digital platforms for design and management, and intelligent systems for automation and diagnostics (Richa, Nirupama, Keshav, Abhishek, Saahil & Anshika, 2024).

The digital world is increasingly penetrating the education and skills domain, with technology gradually being used to deliver education, knowledge and skills in new and innovative ways. Given the increased use of fast changing digital technologies in every workplace and sector including classroom and education generally. New skills needs have emerged…as the use of these technologies has contributed to transforming learning and skills development into a lifelong process (Deebom & Deebom, 2021). Indeed. people now have to continue to develop and refresh their skills and knowledge in order to keep abreast with the constant innovations and new developments in the digital world.

Skill is the learned ability to perform an action with determined results with good execution often within a given amount of time, energy, or both. Skill according to Deebom and Taylor (2020) is described as the ability of corps members (Technical College teachers and students) to be able to carry out a specialized area in entrepreneurial trade (artificial intelligence and intelligent systems) expertly for self-reliance. When the teachers and students acquire skills, it will lead to self-reliance and reduce the level of unemployment. For skill acquisition training programme to have an impact on the society, Deebom and Okwelle (2016) aver that skill acquisition should be tailored and directed towards the youths as they are seen as the frontline for development both rural and urban.

Digital skills are defined as a range of abilities to use digital devices, communication, applications and networks to access and manage information as it helps students to developed learning technologies (Deebom & Deebom, 2021). It also aids lecturers and students to collaborate with each other in terms of learning content. Also, digital skills involve the learning on how to use and adapt the right digital devices, applications, software and systems in finding, reviewing, organizing and sharing information effectively. Digital skills entail the ability of students and lecturers in handling data appropriately and establishing good data security practices as regards to professional conducts.

Digital skills, encompassing proficiency in using various software applications, data analysis tools, online platforms, and digital communication methods, are equally crucial. In the modern Electrical/Electronic trades, technicians are increasingly required to interact with digital schematics, programming interfaces for programmable logic controllers (PLCs) and microcontrollers, cloud-based monitoring systems, and digital documentation. A lack of these skills hinders their ability to effectively collaborate, troubleshoot, and adapt to new technologies.

From the above, it is obvious that the integration of artificial intelligence digital skills into the Electrical/Electronic trades curriculum is no longer a futuristic aspiration but a present-day necessity. AI encompasses a broad range of technologies, including machine learning, natural language processing, computer vision, and robotics, each with the potential to revolutionize how electrical and electronic tasks are performed. For instance, AI-powered diagnostic tools can analyze complex electrical circuits to identify faults with greater speed and accuracy than manual methods (Adib & Ashfakul Karim Kausik, 2024). Intelligent control systems can optimize energy consumption in buildings and industrial processes, contributing to sustainability and cost-effectiveness. Furthermore, AI-driven design software can assist in creating more efficient and reliable electronic circuits and systems.

Similarly, intelligent systems which often incorporate AI and digital technologies are becoming universal and ubiquitous in the practice of Electrical/Electronic trades. These systems can range from smart grids that separately and independently manage power distribution to automated manufacturing lines that produce electronic components with high precision. Ability of the teachers and students of electrical/electronic trades to understand the principles behind these intelligent systems, their operation, maintenance, and potential would further enhance future professional in these trades. It is based on these that this study examines the integration of artificial intelligence digital skills and intelligent systems in electrical/electronic trades in Technical Colleges in Rivers State.

Statement of the Problem

The rapid advancement and increasing adoption of Artificial Intelligence (AI), digital technologies, and intelligent systems are fundamentally transforming industries globally, including the Electrical and Electronic sectors. These technological shifts demand a workforce equipped with a new set of skills that go beyond traditional electrical and electronic competencies. However, Electrical/Electronic trades amongst its aims and objectives are responsible for training future craftsmen, technicians and artisans that are facing a significant challenge in adapting their curricula and pedagogical approaches to adequately address this evolving landscape of artificial intelligence in workplaces.

Currently, the training provided in these Technical Colleges often focuses on foundational electrical and electronic principles and manual skills, with limited exposure to the concepts, tools, and applications of AI, digital technologies, and intelligent systems. This creates a gap between the skills imparted by the educational institutions and the demands of the modern Electrical/Electronic industry in Rivers State. Graduates of electrical/electronic trades subjects are increasingly entering a job market where employers and jobs available require proficiency in areas such as AI-driven diagnostic and maintenance tools, digital design and simulation software, programming and interfacing with intelligent devices and systems, data analysis and interpretation for system performance monitoring, cybersecurity awareness for networked electrical and electronic systems and utilization of digital platforms for documentation, collaboration, and remote diagnostics among others.

The consequence of this skills gap becomes a challenge as graduates of Technical Colleges in Rivers State may face reduced employability and limited career advancement opportunities as they lack the skills increasingly valued by employers in the electrical/electronic sector. Also, industries within Rivers State may encounter difficulties in recruiting a skilled workforce capable of effectively implementing, maintaining, and innovating with AI-driven technologies and intelligent systems, potentially hindering their productivity and competitiveness. These arises as a result of low or poor digitally skilled Electrical/Electronic workforce. It is based on these scenarios that this study on the integration of artificial intelligence digital skills and

intelligent systems in Electrical /Electronic trades in Technical Colleges in Rivers State becomes imperative and significant.

Purpose of the Study

The purpose of the study is to examine the integration of artificial intelligence digital skills and intelligent systems in Electrical /Electronic trades in Technical Colleges in Rivers State. Specifically, the study seeks to find out;

1. The level of awareness of artificial intelligence digital skills and intelligent systems in Electrical/Electronic trades in Technical Colleges in Rivers State.
2. The level of competence of human resources for the integration of artificial intelligence digital skills and intelligent systems in Electrical /Electronic trades in Technical Colleges in Rivers State.
3. The adequacy of material resources for the integration of artificial intelligence digital skills and intelligent systems in Electrical/Electronic trades in Technical Colleges in Rivers State.
4. The challenges facing the integration of artificial intelligence digital skills and intelligent systems in Electrical /Electronic trades in Technical Colleges in Rivers State.

Research Questions

The following questions were answered to guide the study.

1. What are the levels of awareness of artificial intelligence digital skills and intelligent systems in Electrical/Electronic trades in Technical Colleges in Rivers State?
2. What are the level of competence of human resources for the integration of artificial intelligence digital skills and intelligent systems in Electrical/Electronic trades in Technical Colleges in Rivers State?
3. How adequate are the material resources for the integration of artificial intelligence digital skills and intelligent systems in Electrical/Electronic trades in Technical Colleges in Rivers State?
4. What are the challenges facing the integration of artificial intelligence digital skills and intelligent systems in Electrical/Electronic trades in Technical Colleges in Rivers State?

Methodology

The study adopted the descriptive research survey design and was carried out in all the four Technical Colleges in Rivers State which include Government Technical Colleges, Port Harcourt, Government Technical Colleges, Tombia, Government Technical Colleges, Ahoada, and Government Technical Colleges, Ele-ogu. As at the time of this study, Technical Colleges in Rivers State has 133 students and 14 teachers in Electrical/Electronic trades subjects making a total population of 147 respondents (Office of the Principals, 2025). Due this small population, there was no sampling and hence it was a census study. The instrument for data collection was a self-structure questionnaire tagged "Integrating Artificial Intelligence Digital Skills and Intelligent Systems Questionnaire (IAIDSISQ)" which was design after modified 4-point rating scale of awareness, competence, adequacy and agreement with numerical values of 4, 3, 2 and 1 respectively. The instrument was content validated by two experts and tested for reliability through test-retest method. A reliability coefficient of 0.84 was established for the instrument using Pearson Product Moment Correlation (PPMC) coefficient. During administration of the instrument, a total of 147 copies of the instrument were administered while 136 copies (Students = 122; Teachers = 14) were completely filled and successfully retrieved which was used for analysis. Mean with standard deviation was used to answered research questions such that item with mean value greater 2.50 was considered "*Aware*", "Adequate" and *"Agree"* respectively depending on the research question.

Results

The following questions were answered to guide the study.

Research Question 1: What are the levels of awareness of artificial intelligence digital skills and intelligent systems in Electrical /Electronic trades in Technical Colleges in Rivers State?

Table 1: Students' Response on Level of Awareness of Artificial Intelligence Digital Skills and Intelligent Systems

S/N	Item Statement	Mean	SD_1	RMK
1	I'm aware that skills in data analysis are becoming increasingly important in the electrical/electronic trades due to AI applications.	3.21	0.74	**A**
2	I've heard of programming languages like Python being relevant to developing AI-powered tools for electrical/electronic applications.	3.08	0.85	**A**
3	I'm aware that digital skills in areas like cloud computing are important for deploying and managing AI-based systems in electrical/electronic field.	3.33	0.51	**A**
4	I'm aware that the ability to work with sensors and IoT (Internet of Things) devices is linked to AI applications in electrical/electronic trades.	3.48	0.63	**A**
5	I know that skills in digital modeling and simulation are relevant to designing and testing AI-integrated electronic systems.	3.55	1.01	**A**
6	I'm aware of intelligent systems being used for fault detection and diagnostics in electrical equipment.	3.26	0.71	**A**
7	I've heard of smart grids that use intelligent systems to manage power distribution more efficiently.	3.17	0.55	**A**
8	I'm aware that intelligent robots are being used for tasks such as inspection and maintenance of electrical systems in hazardous environments.	2.97	0.81	**A**
9	I'm aware that intelligent automation is being used in manufacturing processes related to electrical and electronic components.	3.03	0.80	**A**
10	I know that intelligent control systems are being implemented to optimize energy usage in electrical installations.	3.41	0.66	**A**
	Average Mean	**3.25**	**0.73**	**A**

Source: *Researcher's Field Result, 2025* A – Aware; NA – Not Aware

Result from Table 1 shows the levels of awareness of artificial intelligence digital skills and intelligent systems in among Electrical /Electronic trades in Technical Colleges in Rivers State. The result revealed that students agree that they are aware of artificial intelligence digital skills and intelligent systems in Electrical /Electronic trades in Technical Colleges in Rivers State with an average mean value of 3.25 which is greater than the cut-off point of 2.50. The finding of this study corroborates with that of Ndom-Uchendu and Nwokike (2024) as found that students are aware that AI enhanced personalized learning, improved engagement, enhanced assessment, increased access to education and improved teacher training are some of the impacts of AI in TVET.

Research Question 2: What is the level of competence of human resources for the integration of artificial intelligence digital skills and intelligent systems in Electrical/Electronic trades in Technical Colleges in Rivers State?

Table 2: Teachers Responses on Competence Level of Human Resources for Integration of Artificial Intelligence Digital Skills and Intelligent Systems

S/N	Item Statement	Mean	SD_1	RMK
11	I possess a strong understanding and competence of fundamental digital skills relevant to AI (e.g., data handling, basic programming concepts).	2.14	1.01	**D**
12	The department have enough competent teachers with specific expertise in areas of Artificial Intelligence such as machine learning or data analytics.	1.84	0.63	**D**
13	Teachers in my college have a general knowledge on artificial intelligence.	3.54	0.81	**A**
14	I've competent practical experience in working with intelligent systems relevant to the Electrical/Electronic trades.	1.93	0.56	**D**
15	Teachers are actively encouraged and supported by the college administration to acquire new skills in AI and intelligent systems.	3.77	0.84	**A**
16	The college has competent personnel with expertise in networking and managing the infrastructure required for intelligent systems and IoT devices.	1.84	1.01	**D**
17	The college have competent IT personnel who can assist with the software and hardware requirements for teaching AI and intelligent systems.	1.25	0.77	**D**
18	There is adequate administrative support available to facilitate the planning and implementation of AI-focused training programs.	3.48	0.47	**A**
19	My college has dedicated competent technical staff who are knowledgeable in maintaining and supporting equipment used for teaching AI-related skills (e.g., computers, sensors, development boards).	1.34	1.01	**D**
20	The current number of teaching staff is adequate and competent to effectively deliver both the traditional Electrical/Electronic trades curriculum and any new AI-related content.	2.03	0.68	**D**
	Average Mean	**2.32**	**0.78**	**D**

Source: *Researcher's Field Result, 2025* A – Agree; D - Disagree

Result from Table 2 shows the level of competence of human resources for the integration of artificial intelligence digital skills and intelligent systems in Electrical/Electronic trades in Technical Colleges in Rivers State. The result revealed that human resources (teachers) are less competent in artificial intelligence digital skills and intelligent systems in Electrical/Electronic trades subjects as shown in an average mean score of 2.32 which is less than 2.50. This finding agrees with Uzo (2021) who identified the need for teachers and students to develop new competences as a challenge in integrating AI into word processing activities in education. Teachers may not be conversant with AI tools or competent enough to integrate them into the curriculum as required.

Research Question 3: How adequate are material resources for the integration of artificial intelligence digital skills and intelligent systems in Electrical/Electronic trades in Technical Colleges in Rivers State?

Table 3: Teachers' Response on Adequacy of Material Resources for Integration of Artificial Intelligence Digital Skills and Intelligent Systems

S/N	Item Statement	Mean	SD_1	RMK
21	Our college has an adequate number of modern desktop computers available for students to learn AI-related digital skills.	3.58	0.74	**A**
22	We have sufficient microcontroller boards (e.g., Arduino,	1.85	0.57	**IA**

	Raspberry Pi) that can be used for projects involving intelligent systems and IoT.			
23	The college provides access to various types of sensors (e.g., temperature, light, motion) that are essential for learning about intelligent systems.	1.33	0.63	**IA**
24	We have access to networking equipment (e.g., routers, switches) necessary for projects involving interconnected intelligent devices.	2.76	0.71	**A**
25	We have specialized hardware like GPUs (Graphics Processing Units) that are beneficial for certain AI tasks like machine learning.	1.49	1.01	**IA**
26	Our college has licensed or free access to relevant programming software and Integrated Development Environments (IDEs) for AI development (e.g., Python, Jupyter Notebook).	1.25	0.70	**IA**
27	We have simulation software that allows students to experiment with intelligent electronic systems in a virtual environment.	1.32	0.81	**IA**
28	Our classrooms and laboratories are equipped with adequate internet connectivity to support online learning and access to cloud-based AI resources.	1.13	1.01	**IA**
29	The software and digital tools available are up-to-date and meet the requirements for learning current AI technologies.	1.84	0.60	**IA**
30	The available hardware is regularly maintained and in good working condition for effective learning.	3.84	0.74	**A**
	Average Mean	**2.04**	**0.75**	**IA**

Source: *Researcher's Field Study, 2025* A – Adequate; IA - Inadequate

Result from Table 3 shows how adequate are material resources for the integration of artificial intelligence digital skills and intelligent systems in Electrical/Electronic trades in Technical Colleges in Rivers State. The result revealed that material resources for the integration of artificial intelligence digital skills and intelligent systems in Electrical/Electronic trades in Technical Colleges in Rivers State are inadequate with an average mean value of 2.04. The finding of this study is corroboration with that of Shuaibu (2024) who aver that adequacy of material resources such as lack of infrastructure and resources needed to implement AI, shortage of qualified trainers and AI experts are some of the significant challenges facing the integration of artificial intelligence digital skills and intelligent systems in institutions.

Research Question 4: What are the challenges facing the integration of artificial intelligence digital skills and intelligent systems in Electrical/Electronic trades in Technical Colleges in Rivers State?

Table 4: Challenges Facing the Integration of Artificial Intelligence Digital Skills and Intelligent Systems

S/N	Item Statement	Mean	SD_1	RMK
31	The lack of sufficient and reliable internet access in our college hinders the effective teaching and learning of online AI resources.	2.66	0.70	**A**
32	There is a shortage of teachers with the necessary expertise and training to effectively teach AI digital skills and intelligent systems in the Electrical/Electronic trades.	3.49	1.01	**A**
33	Attracting and retaining qualified instructors with expertise in both Electrical/Electronic trades and Artificial Intelligence is difficult.	3.08	0.59	**A**
34	Integrating AI content into the already packed Electrical/Electronic trades curriculum is proving to be a challenge.	3.11	0.64	**A**

35	Students may lack the foundational digital literacy skills required to effectively engage with AI-related concepts.	3.36	0.81	**A**
36	Assessing student learning in AI-related areas within the practical context of Electrical/Electronic trades presents unique challenges.	2.97	1.02	**A**
37	Many teachers lack sufficient understanding of the practical applications of AI within the Electrical/Electronic trades.	3.42	0.84	**A**
38	There are limited opportunities for teachers to receive adequate professional development and upskilling in AI-related fields.	3.17	0.73	**A**
39	Our existing laboratory spaces and equipment are not adequately equipped to support practical work in AI and intelligent systems.	3.42	0.68	**A**
40	The cost of acquiring and maintaining specialized AI-related hardware (e.g., GPUs, advanced sensors) is a significant barrier.	3.20	0.82	**A**
	Average Mean	**3.19**	**0.78**	**A**

Source: *Researcher's Field Result; 2025* A – Agree; D - Disagree

Result from Table 4 shows that items listed are challenges facing the integration of artificial intelligence digital skills and intelligent systems in Electrical/Electronic trades in Technical Colleges in Rivers State with an average mean score of 3.19 which is greater than cut-off point of 2.50. The findings of this study are in line with Oguniyi (2019) as opined that one of the primary issues in integrating AI into word processing activities in education is the lack of access to necessary technology and infrastructure. In many educational institutions, students may not have adequate access to the required software or reliable internet. This can leave some students at a disadvantage and hindering their ability to acquire essential word processing and entrepreneurial skills.

Conclusion

The study examines examine the integration of artificial intelligence digital skills and intelligent systems in Electrical /Electronic trades in Technical Colleges in Rivers State. The study concludes that students of electrical/electronic trades in Technical Colleges are aware of artificial intelligence digital skills and intelligent systems. The study further asserts that material resources are inadequate and that human resources are less competent for the integration of artificial intelligence digital skills and intelligent systems in Electrical/Electronic trades in Technical Colleges in Rivers State and hence posses' challenges for its integration.

Recommendations

The following recommendations were made based on the findings of the study.

1. Teaching of electrical/electronic trades subjects in Technical Colleges should include artificial intelligence and intelligent systems since the students are aware of uses.
2. Government should organize training to enhance teachers' competence on AI and intelligent systems since the teachers are less competent on its utilization.
3. Since material resources needed for integration of AI and intelligent systems are inadequate, there should be adequate provision of these resources by government and industries.
4. Special teachers as AI experts should be recruited into the teaching of electrical/electronic trades subjects as this will enhance students' interest and digital literacy skills.

References

Adib, B. R. & Ashfakul Karim Kausik, M. D. (2024). AI revolutionizing industries worldwide: A comprehensive overview of its diverse applications. *Hybrid Advances*, *7*; 47 – 63.

Deebom, M. T. & Deebom, I. (2021). Digital skills needed for the adoption of blended learning approach among Business Education postgraduate students in Rivers State Universities. *Contemporary Issues in Teaching and Learning in Honour of Prof. Wey Augustus Amaewhule*.

Deebom, M. T. & Taylor, D. I. (2020). influence of national youth service corps entrepreneurship skill acquisition programmes on youth empowerment in Rivers State. *International Journal of Humanities Social Sciences and Education (IJHSSE*), 7(6), 146 – 155.

Deebom, M. T. & Okwelle, P. C. (2016). Empowering Rural Youths for Maximum Societal Impact through Skills Acquisition Programme in Ogoni Area of Rivers State. *African Journal of Historical Sciences in Education,* 12(1), 222 – 250.

Ndom-Uchendu, & Nwokike. (2024). Influence of artificial intelligence on delivery of Business Education courses in universities in South-East. *Association of Business Educators of Nigeria* (*ABEN) Conference Proceedings* 11(1), 539-544.

Nie, X. (2020). Research on economic function data and entrepreneurship analysis based on machine learning and computer interaction platform. *Journal of Intelligent and Fuzzy Systems*, *39*(4), 563-581.

Nwosu, C. D., Ekoh-Nweke, A. C., & Zion-Ngoka, C. K. (2024). Application of artificial intelligence in entrepreneurship practice in Nigeria. *Association of Business Educators of Nigeria* (*ABEN) Conference Proceedings 11*(1), 967-958.

Office of the Principals (2025). Number of teachers and students in Technical Colleges.

Oguniyi, M. B. (2019). Innovation approaches to integrating ICT into Nigerian schools for skill acquisition. *Journal of Educational Media and Technology in Nigeria*, *23*(2), 79–95.

Richa, T., Nirupama, S. B. T., Keshav, M., Abhishek, M., Saahil, B. & Anshika, A. (2024). The Impact of Artificial Intelligence in the Workplace and its Effect on the Digital Wellbeing of Employees. *Journal for Studies in Management and Planning*, *10*(4), 1 - 31.

Shuaibu, N. (2024). Integrating artificial intelligence (AI) in vocational education for sustainable development in Africa. In *Proceedings of the 4th International Conference on Administration and Management (ICAM 2024)*. College of Administration and Management Studies, Hassan Usman Katsina, Katsina State, Nigeria.

Uzo, A. (2021). Artificial intelligence in education: Strategies for integration and implementation. *Nigerian Education Research and Development Council (NERDC) Special Issue 12-26.*

Effect of Electric Machine Winding Intelligent Tutor (EMWIT) on Students' Achievements and Performances in Studying Re-Winding of Three-Phase Squirrel Cage Induction Motor in Nigeria.

Ezekoye, Benadeth N., Ph.D.
Department of Industrial Technology Education,
Michael Okpara University of Agriculture, Umudike
Abia State, Nigeria
&
Ogwo, Benjamin A., Ph.D.
Department of Career & Technical Educator Preparation,
State University New York (SUNY), Oswego, USA.

Abstract
This study explores the effectiveness of the Electric Machine Winding Intelligent Tutor (EMWIT) and discusses future directions for integrating Artificial Intelligence (AI) to enhance personalized learning experiences. It aims to determine the efficacy of the Electric Machine Winding Intelligent Tutor (EMWIT) on students' achievements and performances in studying the rewinding of the 3-phase squirrel cage Induction Motor. The study used the quasi-experimental design and a multi-stage random sampling procedure to draw a sample size of 40 electrical students from Government Technical College Nsukka, Enugu State, Nigeria. The subjects included 20 National Technical Certificate (NTC) I students that used the tutor as an individualized learning package and 20 National Technical Certificate (NTC) II students that used the tutor in addition to their teacher's assistance during instructional delivery. The data collection entailed a six-week experiment and the use of two validated instruments. Collected data from the pre-test and post-test were analyzed using mean and standard deviations of the scores that addressed the research questions and a one-way analysis of covariance (ANCOVA) was used to test the null hypotheses at a .05 statistical level of significance. The results indicated that the use of the tutor with or without a classroom teacher was effective in improving knowledge and skills on rewinding a burnt 3-phase squirrel-cage-induction motor. Hence, the tutor is effective when used as a complementary instructional material or as an individualized learning package. The result affirms the utility in deploying EMWIT in various secondary/technical schools to engage in different forms of learning, and skill acquisition on electric motor winding.

Keywords: *Electric Machine, Re-Winding, Intelligent Tutoring System, Quality Teaching and Learning, Students' Achievements and Performances, 3-phase squirrel cage induction motor*

1.0. Introduction

Intelligent Tutors are software applications that use adaptive electronic technologies for personalized instructional delivery. One of their remarkable features is the incorporation of human-tutor interaction. They also offer greater learning flexibility in which students control their own pace of study. According to AbuNaser (2008), intelligent tutors provide personalized computer-based instruction to students. Tutors evolved from the application of artificial intelligence techniques to Computer-Aided Instruction (CAI) systems. The difference is that intelligent tutors usually compare the students' work with experts' solutions or strategies; model the students' knowledge on a domain and provide coaching exercises. An intelligent tutor can simulate the activities of the teacher (human tutor) by presenting subject-matter content within the framework of a computer systems interface and communicating it

intelligently to the users. The presentation could be augmented by the use of videos. Given the instructional potential of video replay, incorporating it into intelligent tutor promises to improve learners' performance in TVE courses like Winding of Electrical Machine (WEM) in Electrical Installation and Maintenance Practices.

Winding of Electrical Machine (WEM) is one of the trade components of Electrical Installation and Maintenance Practices, offered in technical colleges; mostly at National Technical Certificate (NTC) II and III. Winding in an electrical machine is the formation of a magnetic circuit in a machine while the electrical machine is a device that converts mechanical energy into electrical energy (generator) or electrical energy into mechanical energy (electric motor). However, the study focuses on the winding of electric motor specifically the 3-phase squirrel-cage-induction motor because of its common usage in domestic and industrial equipment e.g. water pumps, compressors, millers, grinders, conveyor belts, etc. Its popularity is due to its simple design, inexpensive (half or less of the cost of a DC motor), high power to weight ratio (about twice that of a DC motor), ease of maintenance, and can be directly connected to an AC power source (Bimbhra, 2008 and Mittle & Mittal, 2004). According to the National Board of Technical Education, NBTE, Syllabus (2002), WEM is a module that aims at providing the learner with the knowledge and skill to enable him/her wind or rewind alternating current (AC) and direct current (DC) rotating/static machines up to 10-kilo volt-ampere (KVA). It is expected that on completion of the module, the learner should be able to understand and apply all statutory regulations during electrical winding work, identify and select appropriate tools and equipment used for winding jobs. The learner should acquire skills for dismantling machines for rewinding and understand the rewinding of burnt static/rotating machines. To attain these objectives requires adhering to precise instructions to enable the learner to follow the process and demonstrate the required skill. Unfortunately, this is not possible owing to paucity of instructional materials and other instructional challenges. Hence, if technology is to complement instruction, the emphasis is on providing opportunities to practice skills taught in a classroom setting and extending the classroom learning by using a software application (Kasworn & Londer, 2000). The paucity of such innovative instructional material in Nigeria informed the study's purpose of developing and trial-testing electric machine winding intelligent tutor (EMWIT) that teaches how to rewind burnt electric motor (3-phase squirrel cage Induction Motor).

The developed tutor is delivered in CD-ROMs thus storing a large amount of data together with the use of some high-resolution images. The tutor covers a good range of learning contents in WEM including dismantling of the electrical machine, conductors, and insulating materials used in the winding, construction of former, preparation of winding coils, the connection of winding coils, testing of rewound 3-phase squirrel cage induction motor, and application of varnishing and drying. In each of the learning contents, the learning is sequentially organized and presented with pedagogical principles from learning objectives, instructional materials used, entry behaviour in questions type, presentation of the learning contents, evaluation, summary of the entire learning, and learner's activity. The user cannot proceed to the next lesson until and unless he/she passes the tests. The rest of the content however is thrown open to the learner, thus allowing him/her to take it in any sequence and anytime. The motivational and feedback techniques are also included in the EMWIT. The remediation tasks and storage database information and the practical demonstrations of the tutor are highly effective in facilitating personalized instruction to help the user acquire mastery of winding of the 3-phase squirrel cage induction motor (Ezekoye & Ogwo, 2019). Thus, the present study aims at determining the efficacy of the developed Electric Machine Winding Intelligent Tutor (EMWIT) on electrical students' achievements and performances in studying how to rewind a burnt 3-phase squirrel-cage-induction motor.

2.0. Research Questions

The study was guided by the following research questions:

1. What is the effect of the tutor on the achievement of electrical students that used the tutor solely without a WEM teacher and those that used the tutor with a WEM teacher in learning how to rewind a burnt 3-phase squirrel-cage-induction motor?

2. What is the effect of the tutor on the performance of electrical students that used the tutor solely without a WEM teacher and those that used the tutor with a WEM teacher in acquiring practical skills on how to rewind a burnt 3-phase squirrel-cage-induction motor?

3.0. Hypotheses

Consequent to the research objectives and questions, the following formulated research hypotheses guided the study in its null form and were tested at a .05 level of significance.

Ho1: There is no significant difference ($p \leq .05$) in the mean achievement scores of electrical students who used the tutor solely without a WEM teacher and those that used the tutor with a WEM teacher in learning how to rewind a burnt 3-phase squirrel-cage-induction motor as depicted in the achievement test.

Ho2: There is no significant difference ($p \leq .05$) in the mean performance scores of electrical students who used the tutor solely without a WEM teacher and those that used the tutor with the WEM in acquiring practical skills on how to rewind a burnt 3-phase squirrel-cage-induction motor as depicted in the performance test.

4.0. Research Method

The non-equivalent control group quasi-experimental design was used for the study. According to Gall, Gall & Borg (2007), using a non-equivalent control group design involving more than two groups and having all groups receive a form of treatment, rather than having one group in a no-treatment control condition. Therefore, the two intact classes from the sampled schools (non-randomized groups) were required to use EMWIT to determine its effectiveness. In addition, the research design is considered appropriate because it adopted the non-equivalent control group design and used the One-way Analysis of Covariance (ANCOVA), which is a robust test statistic that can account for any initial differences between the two groups. This study was conducted in South - Eastern Nigeria at Government Technical College (G.T.C.) Nsukka, Enugu State since the school has all the necessary facilities like the workshop, computer laboratory, stand-by generator, and personnel (e.g. WEM teacher) needed for carrying out the research. The population for the study was 62 which comprised, 34 National Technical Certificate (NTC) I and 28 National Technical Certificate (NTC) II electrical students. A random sampling technique was used to draw the subjects and the sample size for the study was 40 which comprised the 20 NTC I, and 20 NTC II electrical students of the college. NTC I electrical students desire to offer a course during their NTC II and they used the tutor solely in learning WEM while NTC II electrical students were already offering the course and they used the tutor with their WEM teacher as a complement to deliver the instruction. The choice of the mixed ability groups of NTC II and I were based on the fact that the developed tutor could be used by individuals of varied abilities. The reason to have the tutor tried out by varied and dissimilar groups is to establish

its robustness and also serve the purpose of scalability of the developed software. Hence, it is an acceptable practice in the software validation process to regard the primary/intended group as the benchmark while any reasonably anticipated groups are used to determine the scope of usage (Situte and Regiald, 1993).

The instruments used in this study were two namely the *Winding of Electric Motor Achievement Test (WEMAT)* and the *Winding of Electric Motor Performance Test (WEMPT).* The items of WEMAT are standardized past National Business and Technical Examination Board (NABTEB) questions, which were developed and validated by National Board for Technical Education (NBTE) original test developers and were designed in two versions (Type I & II) to test students understanding on the winding of electric machine. To ensure its content validity, a test blueprint (Table of Specification) was developed for the test, given due consideration to the emphasis placed on the objectives and major topics in the WEM syllabus for NTC II. Based on the table of specifications, a total of 20 multiple choice items of four optional answers (A-D) were drawn for the WEMAT, carrying 40 marks to be answered within 20 minutes i.e. 2 minutes per question and three essay questions carrying 60 marks to be answered within one hour 20 minutes i.e. approximately 27 minutes per question. The WEMAT marking scheme was also developed and validated. The WEMPT together with the scoring guide was used to test the students' performances on rewinding a burnt electric motor containing 20 rating scale items with four response categories of Excellent (4) Good (3), Fair (2), and Poor (1). The items of WEMPT were generated from the NBTE syllabus on practical competencies in WEM. The two instruments were subjected to both face and content validations. Each of the experts was served with a copy of the instrument together with a test blueprint and NBTE syllabus for NTC II on WEM for validation and was requested to validate the suitability of each item of WEMPT to practical competencies stated in the syllabus and the extent to which the items of WEMAT were in line with the test blueprint. Hence, the corrections and suggestions of these experts served as the guide for the modification and revision of the instruments. The making schemes for WEMAT and the scoring guide for WEMPT were also validated by the experts after whom the few corrections made were reflected in the final draft. In addition, the instruments obtained after validation were subjected to a reliability test. The coefficient of stability of the two versions of WEMAT was established using the test re-test reliability technique. Thus, the test-retest reliability coefficient of WEMAT Type I & II multiple-choice items were found to be .80 and .83 while the essay items were found to be .84 and .70. To establish the reliability of the WEMPT**, t**he inter-rater reliability was established using Kendall's coefficient of concordance and the size of this coefficient of concordance was .89; this indicates that there was high agreement among these three raters. The following measures were taken to control some extraneous variables, which if left unchecked might cause bias in the study. To reduce experimental bias, the regular WEM teacher in the participating school was used to carry out the study. Hence the researcher was not directly involved in the administration of the instrument. To control invalidity that could be caused by teacher variability in the development of the lesson plans and to ensure uniform standards in the conduct of the research, the researcher prepared the teaching instruments (all the lesson plans). Two types of lesson plans were developed: the EMWIT lesson plan for the group without a teacher (NTC I) and the EMWIT lesson plan for the group with a teacher (NTC II). A training workshop was organized for the participating teacher/research assistants on the following; the use of computers in teaching and learning, the use of EMWIT in teaching and learning, and the experimental procedure. Detail explanation was given to them by the researcher before the commencement of the experiment and the training is represented in the Figure 1.

Training Plan for Teachers and Research Assistants			
Day/Activity	**Nature of Activity**	**Objective Targeted**	**Expected Outcome**
1 Introduction	Full details about the study and its expectations were given to the WEM teacher and research assistants. The study aim, objectives, instruments and mode of administration, period of the experiment, and experimental procedures/technique	To provide adequate knowledge of the general overview of the study.	They should be able to understand the study, the instructional procedures for the experiment, and their expected roles.
2 Use of computer	Training on basic use of the computer: booting of computer, use of the keyboard, use of the mouse, the opening of windows and files, saving the document, navigation, use of media player, shutting down of computer	To provide proficiency in the use of EMWIT in the learning process.	They should be able to use the computer in delivering instruction effectively without receiving any assistance.
3 Use of EMWIT in instructional delivery	Use the EMWIT to deliver their lessons on WEM. This involved; conducting mock teaching sessions for the teachers and demonstrations on how to use the study instrument	To improve knowledge and proficiency in the use of EMWIT in the teaching and learning process.	They should be able to use the tutor very well in delivering their lesson on WEM.
4 Use of EMWIT by the teacher	The teachers were allowed to make use of the EMWIT for two days and ask questions for more clarification on; the use of the tutor, instructional procedures, and expectations from the study.	To improve knowledge, proficiency, and interest in using EMWIT effectively and efficiently throughout the study. And to build confidence in using the tutor.	They should be able to use the EMWIT effectively during the training.

Figure 1: Training Plan for Teachers and Research Assistants

However, the lesson plans and EMWIT package (software) was released to them before the commencement of the experiment to enable them to get conversant with them and these packages were uniform in all the treatment groups. It is noteworthy that the validated instruments were for both pre-test and post-test. It is possible to suppose that the use of the same test for both the pre-test and post-test may bring about students performing better in the post-test as a result of test item familiarity. Thus the researcher ensured that the tests were administered with several precautions; the WEMAT was administered in two versions to the students, no student wrote the same version of WEMAT for pre-test and post-test, and the question papers were given to the students in a checkerboard fashion. These were to minimize the chances of obtaining fake scores from students who merely copied from their neighbours. The data collected from the administration of pre-test and post-test were analyzed using the mean to answer the research questions. Any item with a mean response of 3.5 and above was regarded effective (5.00 - 4.50, Very High; 4.49 – 3.50, High) while any item

below 3.5 was regarded not effective (3.49 – 2.50 (Undecided); 2.49-1.50 (Low); 1.49 – 1.00 (Very Low). The pre-test – post-test mean score gains of the two treatment groups were computed to determine the effectiveness of the EMWIT on the students' achievement and performance on rewinding a burnt electric motor. Hypotheses formulated for the study were tested at a .05 level of significance using Analysis of Covariance (ANCOVA) and the pre-test scores as covariates. Thus, when the obtained level of significance is less than or equal to .05, the tested hypothesis is said to be rejected but if the obtained level of significance is greater than .05, the tested hypothesis is said to be accepted. All the analyses were carried out using the Statistical Packages for Social Sciences (SPSS).

5.0. Experimental Procedure

The experimental / instructional procedures for the two groups (I & II) is given as follows:

Steps/Activities / Contents / Objectives	Duration	Teacher's /Research Assistant's Activities	Student's Activities	Learning / Expected Outcome
Step 1 **Administration of Pre-Test Instruments.** The pre-test is aimed at ascertaining students' previous knowledge and proficiency in re-winding a burnt electric motor. This provided baseline data on each of the two dependent variables (achievement and performance) of the groups before the treatment.	5 Hours	The teachers and research assistants administered WEMAT & WEMPPT to all the groups in their various classes together with the answer booklets and sheets. The instruction was to shade in pencil very well on the answer sheet, the answer which bears the same letter as a chosen option. While booklets were provided for the essay section and were to attempt all the questions. A WEMPT evaluation sheet with a 100% score was used by three raters (teachers) to rate the students' abilities on processes as they re-wind a burnt electric motor.	The students attempt all the questions on the instruments and submit them back to the teachers/research assistants with the answer sheets for assessment. They carried out the performance test by re-winding burnt electric motors.	To obtain students' pre-test scores for their Achievement and performances.
Step 2 **1) Training of the students on basic use of computer like** booting of computer, use of the keyboard, use of the mouse, creating and opening of a file, moving from one menu to another, saving of file or document, shutting down of computer and use of media player. **2) Training on the overview of EMWIT:** Meaning, Aim/ Purposes, Features, Uses, and benefits of EMWIT.	2 days of 3Hours per day	Demonstrate on the projector screen: how to boot the system, use the keyboard, and mouse, create & open file, save information on the computer, use of media player, and shut down the system after use. Further, explain the aim of the training as to determine the effect of electrical machine winding intelligent tutor (EMWIT) in learning how to rewind a burnt electric motor. Hence, EMWIT is an individual learning package that emulates human behaviour in teaching the youths and workers, various electrical machine-winding skills. It has Ten lesson contents including workshop safety and small scale business in winding work, video, game,	Listen very attentively and demonstrate on their computer, the teacher demonstrated activities. Ask questions for more clarifications and jot down points. The training was arranged such that every student has a computer for practice.	Achieving a high level of computer literacy enables the use of EMWIT without many difficulties. Student ability to have 75 per cent attendance to enable him/her to participate in Post-test exercise. Ability to state the meaning of EMWIT, its purposes,

3) Training on Experimental procedures: Timetable; Use of attendance register; Use of logbook or training booklet; Dress code and code of conduct; Requirement for practical exercises.		animation, glossary, index, evaluation exercises and feedback, remediation windows, etc. Displaying of the timetable for the training and demonstration on how to fill the Logbook after practical exercise including a record on punctuality and regular attendance to the training.		features, and benefits.
Step 3 **Use of EMWIT in learning how to re- winding a burnt electrical motor**: - How to use this package - How to dismantle a burnt electric motor	2 hours per session	The researcher deployed the developed EMWIT in the school computers laboratory for students to use. **Group II** had a class teacher that used the tutor as complementary instructional material. The teacher asked the students to lunch EMWIT on their individual computers just as the teacher launches the EMWIT on his computer set. The teacher clicks on 'HELP' to give a detailed explanation of how to use the package. The 'HELP' contains the tutorial on how to use the package based on its navigation buttons (Next, Back, Exit, Audio, Video, Menu) and other features like a game, hide text, glossary, index, remediation window, evaluation exercise, and feedback, etc. The teacher also selected the dismantling of an electric motor from the Menu and teaches with it on the Projector screen. **Group I** will use the tutor solely without the WEM teacher. This group is the NTC I electrical students that are yet to offer WEM at their 200 level. Based on the training received from the research assistants, the Group I will be able to launch into the EMWIT environment and were guided throughout the training by EMWIT commands. The developed EMWIT has a feature that asked them to log in by typing in his/her name and clicking on 'HELP' to receive a tutorial on how best to use the tutor and achieve the desired objective.	**Group II** - Each of the students launched the package by double clicking the EMWIT icon on their computer desktop. The students logged in by typing in his/her name in the login bar and clicking on the next icon beside it to welcome him/her into the EMWIT environment. The students also click on 'HELP' to read how to use the package. They also select a topic from the menu and move along with their teacher. **Group I** – the students launched into the EMWIT environment and were being guided throughout the training by EMWIT commands. The student clicked on 'HELP' and received a tutorial on EMWIT features, the navigations, and their uses.	The student should be able to; - access the EMWIT using the computer and personalize the learning process - navigate very well to access information on how to dismantle an electric motor for repairing - Use the glossary, index, and video, audio, hide text, etc. to make learning efficient and productive.
Step 4	At Max., 2	**Group II** - The teacher selected	**Group II** – the	Active

Selection of the following learning content: - Safety in Winding workshop - Dismantling of electric machine - Conductors used in winding - Winding insulation materials - Construction of winding former - Preparation of winding coils - Connection of winding coils - Testing of electrical machine winding - Application of varnish and drying - Winding job Small scale business	Hours per learning content of 9 contacts / visits for the month.	the learning content from the menu bar & Displays it on the projector screen for the explanation. The selection of the topic depended on what he/she had in the scheme of work for the week. **Group I** – the EMWIT allowed them to make the selection in order of sequence.	students selected the learning content from the menu bar and read along with the teacher. They move as will be instructed by the teacher land listen very attentively to the teacher's explanation and demonstrations. They actively participated by putting down points and asking as well as answering the question. **Group I** – the students selected and accessed the learning content of their interest but the training was more student-centred. The students followed the EMWIT commands to advance in the training hence making is self–centred.	participation of the student in the training with at least 65 per cent attendance to qualify him/her to participate in the post-test exercise. They should be able to access all the learning content without difficulties, understand the teaching process and perform very well in all the evaluation exercises.
Step 5 **Student's Activity** Each of the learning content on the EMWIT has its learning activity that will be carried out by the student at end of training on that particular topic. This is to allow the student put into practice what he/she has learnt from the topic in their various workshops as a project since the training is practically oriented. A log book is provided to every student to put down how the activities were carried out in their various workshop and the necessary steps are taken too, to arrive at the desired objective as was specified by the tutor. Hence, the researcher	Not specified	**Group II** – The teacher supervised the students' work as they carried it out in their workshop. This is to ensure the active participation of the students in the practical exercise and to ensure accuracy in their working operations. The teacher also supervises their log books and mate remarks **Group I** – The research assistant supervised this group and their log books. He/she is expected to visit their school workshop at least once a week.	**Group II** – the students carried out the activities in their workshop under the guidance of their WEM teacher. They submitted their log book after every activity to the teacher for proper assessment. **Group I** - students carried out the activity in their workshop under the supervision of the research assistants who came from time to time and their log books was supervised by them.	By the end of training with EMWIT, the student should be able to; Dismantle and re-wind a burnt electric motor with 70 per cent accuracy Carry out necessary inspection and testing on a newly wound motor very well Apply varnish and dry a wound motor perfectly State and observe necessary precautions in winding work Acquire certain

provides all the necessary materials needed for the activities while the tools and equipment will be provided by the student and school / organization.				skills to open a winding workshop
Step 6 **Administration of Post-Test Instruments** This comes up immediately after the training with EMWIT. The same WEMCAT, WEMPPT & WEMII used in the pre-test exercise were administered to all the groups in their various schools and workshop. This is to ascertain students' present knowledge of the course WEM, their proficiency in re-winding a burnt electric motor, and their interest in the trade for their use of EMWIT. This exercise also provided additional data on each of the three dependent variables (achievement, performance & interest) of the groups after the treatment.	5 Hours	The teachers/research assistants administered WEMCAT, WEMPPT & WEMII to all the groups (Group I-students without WEM teacher, Group II- students with WEM teacher) in their various schools and workshops. The instruments with the answer sheet were retrieved back from the students after the exercise and will be marked by the research assistants/teachers. Their scores were collected for analysis in conjunction with pre-test scores. This ended the training exercise and validation process.	The students answered the questions on the instruments and submit for assessment. .	To obtain students' scores for their use of EMWIT on their; - Scores on achievement sequel to the training - Performance following the use of EMWIT - Score on interest after being exposed to the training. - The mean scores obtained shall be used for data analysis in conjunction with the Pre-test scores

6.0. Results

The findings of this study are presented in the tables below and are organised under two subheadings: The influence of EMWIT on electrical students' achievement in learning to rewind of 3-phase squirrel cage induction motor and the influence of EMWIT on electrical students' performance in acquiring practical skills on rewinding of a burnt 3-phase squirrel cage induction motor**.**

A. The influence of EMWIT on electrical students' achievement in learning to rewind of 3-phase squirrel cage induction motor

Table 1: Pre-test and Post-test mean scores and standard deviation of the two treatment groups on the winding of electric motor achievement test (WEMAT).

Treatment Groups	Pre-test Mean/SD	Post-Test Mean/SD	Mean Gain
EMWIT without Teacher (NTC I)	19.10 (6.09)	28.60 (12.06)	9.50
EMWIT with Teacher (NTC II)	24.28 (5.10)	31.11(11.23)	6.83

The data presented in table **1** shows that the treatment group that used the tutor solely without a teacher (NTC I) for learning how to rewind a burnt 3-phase squirrel-cage-induction motor had a pre-test mean score of 19.10 with a standard deviation of 6.09 and a post-test mean score of 28.60 with a standard deviation of 12.06, making a pre-test and post-test mean gain of 9.50. The treatment group that used the tutor with their class teacher as a complement to instructional delivery (NTC II) had a pre-test mean score of 24.28 with a standard deviation of 5.10 and a post-test mean score of 31.11 with a standard deviation of 11.23, making a pre-test and post-test mean gain of 6.83. With these results, the use of EMWIT solely or as a compliment is effective in improving students' achievement on the winding of the 3-phase squirrel-cage-induction motor but the effect was higher in the group that used it solely than in the group that used it with their class teacher. The Analysis of Covariance (ANCOVA) for the test of significance is presented in table 2 below.

Table 2: Summary of the One-Way Analysis of covariance (ANCOVA) for the test of significance on the effect of EMWIT on the achievement of the two groups.

Dependent Variable: WEMCAT Post-test

Source of Variation	Type III Sum of Squares	Df	Mean Square	F	Sig.	Eta Squared
Corrected Model	1143.718[a]	2	571.859	5.236	.010	.230
Intercept	176.448	1	176.448	1.616	.212	.044
Pre-test	1083.980	1	1083.980	9.925	.003	.221
Treatment Group	49.317	1	49.317	.452	.506	.013
Error	3822.598	35	109.217			
Total	38688.000	38				
Corrected Total	4966.316	37				

a. R Squared = .230 (Adjusted R Squared = .186)
b. Significant at sig of F < .05, Not Significant at sig of F > .05
c. F(1, 35) = .45, p= .51, partial eta squared = .23

The data presented in Table **2** shows a one-way between-groups analysis of covariance that was conducted to compare the effect of the developed EMWIT on two different groups of students; NTC I electrical students (EMWIT without a teacher) and NTC II electrical students (EMWIT with the teacher) in teaching and learning to rewind of 3-phase squirrel-cage-induction motor as shown in their winding of electrical motor achievement test (WEMAT). The independent variable was the type of the treatment group (NTC I & NTC II), and the dependent variable consisted of scores on the WEMAT after the experiment was completed (Post-WEMAT). Students' scores on Pre-test administration of WEMAT (i.e. Pre-WEMCAT) were used as the covariate in this analysis. The F-calculated value at the degree of freedom (1, 35) is .452 with a significance value of .506, which is above the confidence level of .05. Thus, the null hypothesis (Ho_1) is accepted at a .05 level of significance stating no significant difference between the mean achievement scores of electrical students that used EMWIT solely without a teacher (NTC I) and students that used EMWIT with the teacher (NTC II). Therefore, the use of EMWIT with or without a teacher is effective in teaching and learning how to rewind a burnt 3-phase squirrel-cage-induction motor.

B. The influence of EMWIT on electrical students' performance in acquiring practical skills on rewinding of a burnt 3-phase squirrel cage induction motor

Table 3: Pre-test and Post-test mean scores and standard deviation of the two treatment groups on the winding of electric motor performance test (WEMPT).

Treatment Groups	Pre-test Mean / SD	Post-Test Mean / SD	Mean Gain
EMWIT without Teacher (NTC I)	24.27 (1.62)	54.87 (4.42)	30.60
EMWIT with Teacher (NTC II)	27.07 (5.64)	59.36 (9.82)	32.29

The data in table **3** shows that the treatment group that used the tutor solely without a teacher in learning how to rewind a burnt 3-phase squirrel-cage-induction motor had a pre-test mean score of 24.27 with a standard deviation of 1.62 and a post-test mean score of 54.87 with a standard deviation of 4.42, making a pre-test versus a post-test mean gain of 30.60. The treatment group that used the tutor with their class teacher as a complement to instructional delivery had a pre-test mean score of 27.07 with a standard deviation of 5.64 and a post-test mean score of 59.36 with a standard deviation of 9.82, making a pre-test versus a post-test mean gain of 32.29. With these results, the use of EMWITs solely or as a complement in teaching and learning winding of electrical machine is effective in improving students' performance on rewinding a burnt 3-phase squirrel-cage-induction motor but the effect was higher in the group that used it with their class teacher than the group that used it solely. The Analysis of Covariance (ANCOVA) for the test of significance is presented in table 4 below:

Table 4: Summary of one-way analysis of covariance (ANCOVA) for the test of significance of the effect of EMWIT on the performance of the two groups

Dependent Variable: WEMPPT Post-test

Source of Variation	Type III Sum of Squares	Df	Mean Square	F	Sig.	Eta Squared
Corrected Model	149.430[a]	2	74.715	1.275	.296	.089
Intercept	2008.699	1	2008.699	34.280	.000	.569
Pre-test	3.412	1	3.412	.058	.811	.002
Treatment	115.890	1	115.890	1.978	.171	.071
Error	1523.536	26	58.598			
Total	96008.000	29				
Corrected Total	1672.966	28				

a. R Squared = .089 (Adjusted R Squared = .019)
b. Significant at sig of F < .05, Not Significant at sig of F > .05
c. F (1, 26) = 1.98, p = .17, partial eta squared = .09

The data presented in Table **4** shows a one-way between-groups analysis of covariance that was conducted to compare the effect of the developed EMWIT on two different groups of students in acquiring practical skills on how to rewind a burnt 3-phase squirrel-cage-induction motor as shown in a performance test (WEMPT). The independent variable was the type of the treatment group (NTC I & NTC II), and the dependent variable consisted of scores on the WEMPT after the experiment was completed (Post-WEMPT). Students' scores on Pre-test administration of WEMPT (i.e. Pre-WEMPT) were used as the covariate in this analysis. The F-calculated value at the degree of freedom (1, 26) is 1.98 with a significance value of .171, which is above the confidence level of .05. Thus, the null hypothesis (Ho_2) is accepted at a .05

level of significance stating a no significant difference between the mean performance scores of electrical students that used EMWIT solely without a teacher (NTC I) and those that used EMWIT with a teacher (NTC II) in acquiring practical skills on rewinding of a burnt 3-phase squirrel-cage-induction motor as shown in a performance test (WEMPT). Therefore, the use of EMWIT is effective in acquiring practical skills on how to rewind a burnt 3-phase squirrel-cage-induction motor.

7.0. Discussion of Results

The findings of this study on the influence of EMWIT on electrical students' achievement in learning to the rewinding of 3-phase squirrel-cage-induction motor as shown in tables 3 and 4 are similar to findings of several other studies conducted on intelligent tutoring systems (ITS). According to Jim and Sowmya (2000), research on prototype systems indicates that ITS-taught students generally learn faster and translate the learning into improved performance better than classroom-trained participants. They further stated that at Carnegie Mellon University, for example, researchers developed an intelligent tutoring system called LISP Tutor in the mid-1980s that taught computer programming skills to college students. In one controlled experiment, students who used the intelligent tutor scored 43 per cent higher on the final exam than a control group that received traditional instruction when given complex programming problems, the control group required 30 per cent more time to solve these problems, compared to the ITS students. Also, another ITS known as Sherlock was developed in the early 1990s to train Air Force personnel on jet aircraft troubleshooting procedures. Learners taught using Sherlock performed significantly better than the control group and, after 20 hours of instruction, performed as well as technicians with four years of on-the-job experience. Thus, depending on the extent of artificial intelligence and cognitive science, intelligent tutors are becoming a very popular and effective domain in education for many reasons: better student performance, the student learns in less time and the student is more in the driver's seat (Graesser & Pearson, 2001). Generally, the primary motivation for integrating ICT in education is that it supports pupils in constructing their knowledge, allows them to transcend their cognitive limitations, and emerges them in cognitive operations they may not have been capable of otherwise (Salmon, 2000). Many large-scale studies have documented the positive learning outcomes of using ICT in schools (Wenglinsky, 1998; Mann, Shakeshaft, Becker & Kot-Tkamp, 1999). These studies claimed that ICT develops a culture of thinking; one that engages students with challenging yet personally meaningful problems draws on students' conceptual and cultural world of experiences and promotes active and independent learning among students.

The use of EMWIT with or without a teacher was effective in improving students' psychomotor performance in acquiring practical skills on rewinding a burnt 3-phase squirrel-cage-induction motor but the effect on the group that used it with a teacher (NTC II) was higher than the group that used it without a teacher (NTC I). Hence, there was no significant difference between the mean rating of the two groups (NTC I students that used EMWIT without a teacher and NTC II students that EMWIT with a teacher) on their psychomotor performance in rewinding a burnt 3-phase squirrel-cage-induction motor. The plausible significance of the findings on the effect of EMWIT on electrical students' performance in acquiring practical skills on rewinding of a burnt 3-phase squirrel-cage-induction motor is in facilitating capacity building of TVE students, which also entails enhancing the teachers' competencies in curriculum implementation (Eze & Okoye, 2008). Therefore, if technology is used to complement instruction, the emphasis is on providing opportunities to practice skills taught in a classroom setting and extending the learning by working with a specific software application (Kasworm & Londoner, 2000). In addition, this finding has implications for the

open and distance learning (ODL) environment, where the teaching of practical skills poses considerably more difficulties than the teaching of theory (Hampton, 2002). Teaching practical skills is very different from teaching theory and it requires some special considerations. Within an educational institution, the learning of practical skills is most often associated with workshops and laboratories, specialist materials and equipment, smaller class sizes, and frequently, longer blocks of time for practice or try-out. The study's finding also indicates that learners equally received theoretical explanations when using an intelligent tutor to acquire vocational skills. Fenrich (2005) states that when individualized instruction is well designed, students can work at their own pace, proceed when they are ready, and control their learning path. The tutor can aid them in reviewing as often as they want, experience an infinitely patient tutor, be actively involved in their learning and have immediate feedback, be evaluated, learn privately without peer competition, learn when there is a need, and learn when they want. Hence, it is plausible to postulate that if the group without a teacher were given ample time to work at their own pace, control their learning path, and review as often as they want, they would have performed better than they did.

However, the knowledge acquisition for the student model of intelligent tutoring systems (ITSs) remains a difficult problem, partly because of the complexity associated with understanding both how people learn and how it is best to tutor (Cheung, Hui, Zhang & Yiu, 2003), much of which relates to metacognition and problem-solving skills. In the past, explanations of differences in the ways that people learn have focused on cognitive factors having to do with thinking and information processing, such as learning styles. However, that is not the only key source for individual learning differences. Pedagogy or andragogy model is a crucial assumption about the characteristics of learners that consider the whole-person perspective in terms of diagnosis of needs, learning climate, and role of their experiences. Considering this, an appropriate learning orientation such as pedagogy or andragogy should be considered when developing an intelligent tutor since ITS will be used independently, and the level of student self-directedness might influence their learning experience, interest, and performance.

8.0. Conclusion and Recommendations

This study of intelligent tutoring system expects that, it will bridge the gap between the theoretical side of the education and learning of technical and vocational subjects and the practical side of what is feasible to implement in actual classrooms. Hence, this study describes an effort to validate an innovative and fully functional electric machine winding intelligent tutor for the TVE programme. The study revealed that the use of EMWIT with or without a classroom teacher is effective in improving knowledge and skills on rewinding a burnt 3-phase squirrel-cage-induction motor. This implies that EMWIT is effective when used as complementary instructional material or as a stand-alone medium for learning the winding of a 3-phase squirrel-cage-induction motor. Learners of the electrical engineering trade could use the tutor on their own as an individualized learning package to develop and up-skill their learning skills and competency in the winding of a 3-phase squirrel-cage-induction motor. Teachers of the electrical engineering trade could adopt the use of EMWIT to complement their instructional delivery thereby improving the methodology for teaching the students and stimulating students' interest in the winding of electrical machines. In addition, given the large global need for developing vocational and technical skills; the challenges of teaching vocational and technical skills, EMWIT, represents a modest effort at developing an intelligent tutor on the winding of a 3-phase squirrel-cage-induction motor. This study, therefore, recommends that teachers and learners in the field of electrical engineering trade should adopt the use of the developed software, EMWIT, in enhancing the teaching and learning of rewinding of the 3-phase squirrel-cage-induction motor, since it promotes

students/learners to engage in many forms of intellectual growth and skill acquisition. In addition, the TVE curriculum for electrical engineering trade needs to be reviewed with the view to incorporating the use of digital technologies like EMWIT into teaching and learning.

9.0. Future Directions: Integrating AI into EMWIT

The integration of Artificial Intelligence (AI) into the Electric Machine Winding Intelligent Tutor (EMWIT) represents a significant advancement in educational technology. By harnessing AI's capabilities, EMWIT can offer personalized learning experiences tailored to individual students' needs and abilities. This adaptive approach enables students to focus on areas where they require improvement, thereby enhancing their understanding and retention of complex concepts related to rewinding three-phase squirrel cage induction motors.

Key Benefits

- *Personalized Learning Paths*: AI analyzes student performance and adapts the learning content accordingly.
- *Intelligent Feedback:* AI-powered feedback mechanisms help students identify knowledge gaps.
- *Enhanced User Experience:* AI-driven interfaces make EMWIT more intuitive.

Future Directions: The development and evaluation of AI-powered EMWIT hold promise for revolutionizing electrical engineering education. Future research can explore:

1. Developing AI-powered adaptive learning pathways.

2. Implementing intelligent feedback mechanisms.

3. Enhancing user experience through AI-driven interfaces.

By integrating AI into EMWIT, educators can create more personalized, effective, and engaging learning experiences for students.

10.0. References

Abu Naser, S.S (2008). Developing an intelligent tutoring system for students learning to program in C++; *Information technology Journal* 7(7), 1055 -1060.

Bimbhra, P. S. (2008). *Electrical Machinery*. Delhi (Seventh edition): Khanna Publishers, Nai Sarak.

Cheung, B., Hui L., Zhang, J. & Yiu, S. (2003). Smart Tutor: An Intelligent tutoring system in web-based adult education. *The Journal of systems and software***.** 68, 11 – 25

Eze, T. I. & Okoye, K. R. E. (2008). Instructional delivery system in technical and vocational education at the secondary education level in Nigeria. *A keynote address at the National Association of Teachers of Technology (NATT) workshop on capacity building in instructional delivery in TVE at the secondary education level in Nigeria held at* Federal College of Education (Technical) Umunze from Sept., 15 – 18, 2008.

Ezekoye, B. N. & Ogwo, B. A. (2019). Motivational and Remediation Effectiveness of an Electric Motor Winding Intelligent Tutor (EMWIT). *Review of Education*, 31 (2) 246 - 261. Publisher: Institute of Education, University of Nigeria, Nsukka.

Federal Government of Nigeria (2004). *National policy on education* (4th Ed**)** Lagos NERDC press.

Fenrich, P. (2005). *Creating instructional multimedia solutions: practical guidelines for the real world.* Santa Rosa, CA: Informing science press.

Fisher, C., Dwyer, D. C. & Yocam, K. (1996). *Education and technology: Reflections on computing in classrooms*. United States: Jossey – Bass Publishers (San Francisco)

Graesser, A. C & Parson, N. K (2001). *Teaching tactics and dialog in auto tutor*. Int. Artificial Intel. Eduuc, 12, 12 – 23.

Gall, M. D., Gall, J. P. & Borg, W. R. (2007). *Educational research: An introduction*, Boston: Pearson Educational Inc.

Hampton, C. (2002). Teaching practical skills. In A. K. Mishra & J. Barbam (Eds) perspectives on distance education: skills development through distance education (chap 9) Retrieved on August 28, 2008, from *http://www.col.org/skills/skills-development.pdf*.

Jim O. and Sowmya R. (2000). Intelligent Tutoring System: The what and the how. Retieved on 31/03/08 from http://www.learningcircuits.or/2000/feb2000/ong.htm.

Kasworm, C. E. & Londoner, C. A. (2000). Adult learning and technology. In A. L. Wilson & E. R. Hayse (Eds.). *Handbook of adult and continuing education.* San Franciso, CA: Jossey-Bass.

Kukia, E., Nguyen, N.T & Sobecki, J. (2002). The consensus-based tutoring strategy selection in CAL systems. *World transactions on engineering and technology education* (1) 95-98.

Mann, D., Shakeshaft, C., Becker, J. & Kot-Tkamp, R. (1999). West *Virginia's basic skills/computer education program: An analysis of student achievement*. Santa Monica, CA: Milken Family Foundation.

Mittle, V. N. & Mittal, A. (2004), *Design of Electrical Machines* (Fourth edition). Delhi: Standard Publishers Distributors, Nai Sarak.

Salmon, G. (2000). *E-moderating strategies for delivering knowledge in the digital age*. New York: McGraw-Hill

Shepard, L. A. (1997). The centrality of test use and consequences for test validity. *Educational Measurement: Issues and Practice*, 16 (2), 5-8, 13, 24.

Situte, V. J. & Regiald, J. W. (1993). Principles for evaluating intelligent tutoring systems. *Journal of Artificial Intelligence and Education* 4 (2/3), 245 – 271.

Sowmya, R. (2008). A meta-cognitive computer-based tutor for high-school algebra, Retrieved on 31/03/08 from *http://www.stottlerhenke.com/papers/ramach&ran_algebra_tutor.pd.*

Ukoha, U. A. & Eneogwe, U. N. (1996). The instructional process. In B. A. Ogwo (Ed) *Curriculum development and educational technology* (89 – 154). Markurdi: Onaivi Printing & Publishing Co.

UNESCO & ILO (2002). *Technical and Vocational education and training* for the twenty-first century. UNESCO and ILO Recommendations. Paris: Authors

Wenglinsky, H. (1998). Does it compute? The relationship between educational technology and student achievement in mathematics. *Educational Testing Service Policy Information Center*.

APPLICATION OF ARTIFICIAL INTELLIGENCE IN TEACHING AND LEARNING OF ELECTRONIC TECHNOLOGY IN COLLEGES OF EDUCATION IN NIGERIA

BY

[1]GARBA Zakariya'u, [2]MUHAMMAD MUHAMMAD Bodinga & [3]KABIRU Muhammed

[1]Department of Technical Education, Shehu Shagari College of Education, Sokoto
[2]Department of Fine and Applied Art, Shehu Shagari College of Education, Sokoto
[3]Technical Education Department, Federal College of Education Gidan Madi, Sokoto State

Abstract
This paper intends to examine the impact of artificial intelligence (AI) in teaching and learning of Electronic Technology in colleges of education in Nigeria. With the rapid advancement of AI technologies, educational institutions are increasingly incorporating AI-driven tools and methodologies to enhance pedagogical practices and learning outcomes. This review synthesizes existing literature on the integration of AI in curriculum design, instructional strategies, and assessment techniques within the context of Electronic Technology Education. Key applications such as intelligent tutoring systems, adaptive learning platforms, and AI-powered simulations are discussed, highlighting their potential to foster personalized learning experiences, improve student engagement, and facilitate skill acquisition. Furthermore, challenges such as resources constraints and cost, technical limitations, and ethical considerations are addressed, underscoring the need for strategic implementation. The findings suggest that while the adoption of AI in Electronic Technology Education presents significant opportunities for innovation, a concerted effort is required to overcome existing barriers and fully realize its potential in enhancing educational practices in Nigerian colleges of Education.

KEY WORDS: *Artificial Intelligence (AI), Electronic Technology Education, Teaching and Learning*

Introduction

The rapid advancement of technology has necessitated a corresponding evolution in educational practices. As technology continues to play an integral role in society, the role of Artificial Intelligence (AI) in education cannot be overlooked. In Nigeria, the significance of AI in enhancing Electronic Technology Education (ETE) in colleges of education is becoming increasingly apparent. Muresn (2023) asserted that the use of AI has become increasingly present in our lives, having a significant impact in various fields, including education, this is the fact that Education has undergone a series of changes and under the impact of artificial intelligence that brings with it the opportunity to transform and adapt the way teaching/learning process is carried out. This current technology (AI) is beneficial for organizations and individuals as it can increase efficiency, productivity, save time and effort, and improve overall performance and therefore become one of the key technological drivers and trends in the 21st century. (Tahrim, Hassan & Shagoo, (2024). The need to find out the impact that artificial intelligence is having on education as we know it, and how we can use the discovery to improve the experiences of students and teachers in electronic technology education. This paper aims to review existing literature on AI applications in ETE and assess their impact on pedagogical practices and learning outcomes.

These technology (AI) is therefore considered as the set of competencies that enables individuals to carry out a function being it commercial, educational or humanitarian effectively and collaboratively via online tools.

Conceptual Framework

Artificial Intelligence in Education

Artificial intelligence (AI) according to Allam, Dempere, Akre & Flores (2023) is the latest technology encompasses the combination of applications of machine learning, deep learning, algorithm production, and natural language processing mechanism. It's a tool that simulate human intelligence processes by machines, particularly computer systems. Magerko (2020) define artificial intelligence as "a set of competencies that enables individuals to critically evaluate AI technologies, communicate and collaborate effectively with AI, and use AI as a tool online, at home, and in the workplace". Allam et al (2023) refers AI the process of utilizing computer machines to think and act humanly and rationally. According to this definition AI is classified into four categories, those that can act humanly, think humanly, act rationally and think rationally.

Haugeland (1989) in Tahir et al (2024) identified those AI that think humanly as the exciting new quest to make computers think or to have robots with brains in the literal sense. It is also defined as the automation of tasks associated with human thought, such as decision-making, problem-solving, and learning. Furthermore AI in terms of human mimicking (AI that act humanly) is considered as the art of machine design that execute variety of activities that require intellect when perform by people, Tahrim et al (2024) further expressed AI that act humanly as ''the study of how to make computers do things at which, at present, people are superior''.

Looking at the AI from the rationality point of view AI is defined as the study of mental capabilities through the use of computational models (charniak in Tahir 2024).

Artificial intelligence in education AI therefore, is the process of utilizing computer and all its associated auxiliaries to intelligently carried out functions humanly with variety of applications that include adaptive learning systems, intelligent tutoring systems, automated grading, and learning analytics.

Electronic Technology Education

The area of education designed to provide training for individuals interested in electronics works and competent in repairing electronics appliances, installing and performing routine preventive maintenance on electronic appliances through fault diagnosis, repairs and constructing new electronic circuits, consequently, providing employment opportunities for earning a living is referred to as electronic technology education (ETE), (Okolocha & Baba, 2016). This area encompasses the study of electronic devices, circuits, and their applications in technology. It combines theoretical knowledge with practical skills, emphasizing hands-on experience and problem-solving (Adebisi & Olanipekun, 2020).

With emergence of artificial intelligence tool digital simulations and e-workshop practice will be available for both teachers and student since practical skills acquisition is key component of teaching ETE in colleges of education. Incorporating of AI teaching does not only ease the work of the teachers but also facilitate student understanding of ETE in all ramifications.

Applications of AI in Electronic Technology Education

Artificial intelligence tools are found worthy in various aspect of teaching and learning including the area of electronic technology education, its applications range from intelligence tutoring system/Feedback, assessment/automatic grading system, learning analytics/content design and virtual/argumentative reality.

Intelligent Tutoring Systems

Intelligent Tutoring Systems (ITS) are AI-driven platforms that provide personalized feedback and learning experiences (VanLehn, 2011). In ETE, ITS can adapt instructional

content to meet individual student needs, thereby enhancing the learning process. Guo, Wang & Gu (2021) identified that, ITS employed the AT techniques to provide personalized instruction and feedback to students via the computer-assisted instructions and Geometry tutor had evidently demonstrated the efficacy of AI-driven system thus improving the students learning outcomes.

Automated Grading Systems

The use of Artificial Intelligence played a vital role in automating administrative task and grading system of student's educational outcome. Farahani and Ghasmi (2024) reported that, AI technologies automate routine administrative tasks, such as grading assessments, scheduling classes, and managing resources, thereby freeing up educators' time to focus on instructional planning, collaboration, and student interactions. Automated grading systems can efficiently assess students' performance in practical tasks and theoretical examinations. This helps educators save time and provides immediate feedback to students (Baker *et al.*, 2019). Furthermore, AI technologies automate routine administrative tasks, such as grading assessments, scheduling classes, and managing resources, thereby freeing up educators' time to focus on instructional planning, collaboration, and student interactions.

Learning Analytics

Learning analytics involve the collection and analysis of data related to learners and their contexts. By using AI, educators can identify trends, predict student outcomes, and intervene when necessary to improve learning (Siemens & Long, 2011). With use of AI, teaching and learning content can easily be design and make it flexible and user friendly. Culican 2024 in Tahrim, et al (2024) stated that AI algorithms can scan large data to tap into the gaps thus creating content that is interesting and trendy. Furthermore, AI can also be used for making content including textbooks, personalized learning materials, and interactive courses according to the target audience. AI tools enable the development of educational material that is based on natural language processing capabilities thus ensuring material that is consistent, concise, and grammatically correct (Dawes, 2023).

Virtual and Augmented Reality

AI can enhance learning through virtual and augmented reality tools that simulate real-world environments for practical training in ETE (Chen *et al.*, 2020). This creates immersive learning experiences that are critical for understanding complex concepts. In the area of content delivery, AI achieved this very efficiently, flexible and concise by replacing physical classroom activities with its equivalent virtual form, thus providing support for students to learn from anywhere any time globally. Tahrim etel (2024) reported that, In the future, AI systems might replace lecturers in some subjects. Currently, some educational programs are equipped with AI, and scaffolding students to learn basic skills. The benefits of using AI for delivering educational content include the provision of individualized and customized learning, and universal access for all students who may speak different languages or have some disability such as visual or hearing impairment (Marr, 2024). Furthermore, according to Dawes (2023), AI can be used to analyze advanced insights about how students are receiving educational delivery and making progress thus enabling a more personalized learning experience. Thus, it can be argued that AI-based education delivery is more learner-centric compared to the traditional method of educational delivery and is beneficial for learners as well as tutors.

Benefits of AI in ETE

Enhanced Learning Experience

AI applications can create engaging and interactive learning environments, catering to diverse learning styles and preferences (Li *et al.*, 2020). AI-driven intelligent tutoring systems provide

real-time feedback, guidance, and scaffolding to students as they navigate learning tasks and activities. Educators can leverage AI tools to deliver more effective instruction, identify student misconceptions, and intervene proactively to support student learning (Farahani et at, 2024).

Improved Educational Outcomes

Research indicates that AI can significantly improve student performance and retention rates through personalized learning (Katz & Aharony, 2019). The use of AI in teaching and learning process can be of great benefits to both teachers and student by creating room for them to personalized learning, adaptive learning, instructional support enhancement, data-driven insight and free access to high-quality educational resources among others, Farahani et al 2024.

Teacher Support

This includes issues like installation, operation, maintenance, network administration and security. This is an important part of the implementation and integration of AI in ETE education system. In most cases however, technical support is not available, which implies that trainers and students require some basic troubleshooting skills to overcome technical problems when using AIs (Karthikeyan, 2014). Appropriate strategies should be in place to ensure that integration of AIs in teaching and learning of ETE alongside with the recruitment, training, retaining and retention of required and adequate staffs.

AI tools can assist educators by providing insights into student performance and areas needing enhancement, thus allowing them to focus on teaching (Davis, 2021).

Challenges of AI Implementation in Teaching and Learning of ETE

While struggling to adopt with new technology in teaching and learning processes a lot of barrier/constraints hinder the smooth running of the program and this is not different with use of AI in teaching and learning processes. Some of the challenges associated with use of AI in teaching and learning of ETE are; privacy concerns, inclusion and ease of accessibility, technical limitations, resources constraints and their associated cost, lack of human interaction and general ethical concerns among others.

privacy concerns: while AI collect a wide range of student data it becomes an issue of concern that how this information is protected against cyberbullying, hackers and other online misconduct.

Inclusion and ease of accessibility: this becomes a matter of concerns as many students in developing countries have no access to smart phones and even data to utilize AI technology as compared to their counterpart in developed countries and this hinders smooth implementation of AI in teaching and learning generally.

Technical limitations: Implementing AI requires training a large number of tutors and educational managers to use the system which may not be an easier task. The educational system of many countries is not up to date to accommodate such change and thus it remains a challenge.

Resources constraints and their cost: Many Nigerian colleges face inadequate technological infrastructure, where available are either absolute or are not in good working conditions making the adoption of AI in teaching very challenging.

Lack of human interaction: AI may not be able to replicate the emotional connection and support that comes from interactions with human teachers and peers, potentially leading to feelings of isolation for students.

General ethical concerns: While utilizing AI tools in education issues of transparency, fairness, privacy, morality, and removal of bias need to be address in other to protect the integrity of students whose data may always be available online.

Conclusion

In conclusion, the incorporation of AI in teaching and learning of electronic technology education hold a significant role and promise to facilitate students learning process thereby personalizing instructional processes and provide real-time feedback thus improve the learning outcomes. This review paper discussed the application of AI tools use in education, which includes intelligent tutoring, analytic learning, automated grading system, virtual and argumentative reality among others. As a result of AI integration in teaching and learning processes students learning experience can be enhanced and their learning outcome improved. The key challenges discussed in this paper are ethical concerns, privacy concerns, technical limitations, resources constraints, lack of human interactions and inclusion with ease of accessibility. When the said challenges are address, more effective, inclusive and engaging learning outcomes can be realized by the educators.

Recommendations

Based on the documents reviewed in this article and point earmarked, the following recommendations are made;

- Government should invest more capital in technological infrastructure
- Training and re-training should be organized to ETE teachers to keep them UpToDate with current knowledge of AI tools use in education
- Adequate and un-interrupted power supply, internet connectivity and other ICT gadgets should be provided to colleges for ease implementation of AI into teaching and learning

References

Allam, H. et al (2023). Artificial Intelligence in Education (AIED): Implications and Challenges.
Proceedings of the HCT International General Conference (HCT-IGE2023), *Atlantic Highlights in social sciences, education and humanities 13*

Charniak, M. (1985). *Introduction to artificial intelligence. Pearson Education India,*

Culican, J. (2024). The impact of AI on educational content creation: shaping the future of learning materials. Available from https://www.linkedin.com/pulse/impact-ai-educational-content-creation-shaping-future-jamie-culican-o7nxe

Dawes, S. (2023). How AI can deliver personalised learning and transform academic assessment.
Available from https://www.unisa.edu.au/connect/enterprise-magazine/articles/2023/how-ai-can-deliver-personalised-learning-and-transform-academic-assessment/

Farahani, M.S. & Ghasmi, G. (2024). Artificial Intelligence in Education: A Comprehensive Study. Forum for education studies; 2(3):1379. https://dio.orh/10.59400/fes.v2i3.1379

Guo, L., Wang, D. & Gu, F. (2021). Evaluation and Trends in Intelligence Tutoring Systems Research: A multidisciplinary and scientometic view. *Asia pacific education review. 2021; 22(3)*

Haugeland, J. (1989). *Artificial Intelligence: The Very Idea*. MIT Press.

Karthikeyan, P. (2014). Electronic Technology in Teaching Learning Process. Shandex *international journal of education* vol. 3 No 1 December, 2014 ISSN:2320-26.

Marr, B. (2024). How is AI used in education — real world examples of today and a peek into the future. Available from https://bernardmarr.com/how-is-ai-used-in-education-real-world-examples-of-today-and-a-peek-into-the-future/

Muresan, M. (2023). Impact of Artificial Intelligence on Education Research Association for Interdisciplinary Studies. Doi:10.5281/zenodo.8132828 june, 2023

Tahrim, M., Hassan, F.D., & Shagoo, M.R. (2024). Role of Artificial Intelligence in Education:

A Conceptual Review. *World Journal of Advance Research and Reviews* Eissn:2581-9615 CODEN (USA): WDARAI April 2024

UTILIZATION OF DIGITAL SKILLS AND ARTIFICIAL INTELLIGENCE FOR TEACHING AND LEARNING OF ELECTRICAL/ELECTRONICS TECHNOLOGY FOR 21ST CENTURY ECONOMIC DEVELOPMENT

BY

Afaor, Nathaniel Nguuma PhD
nathafaor@gmail.com
Ajula, Matthew Ter
ajulamatthew@gmail.com
Jato, Solomon Daniel
jatods@gmail.com
DEPARTMENT OF INDUSTRIAL TECHNOLOGY
REV. FR. MOSES ORSHIO ADASU UNIVERSITY, MAKURDI
AND
Jacob Terzulum Dura
jacobdura4@gmail.com
DEPARTMENT OF INDUSTRIAL TECHNICAL EDUCATION
JOSEPH SARWUAN TARKA UNIVERSITY MAKURDI

Abstract

The 21st century is characterized by rapid technological advancements that are reshaping education and workforce demands across all sectors, including Electrical/Electronics Technology (EET). This paper explores the utilization of digital skills and artificial intelligence (AI) in teaching and learning EET as a strategic driver for sustainable economic development. Digital competencies enable educators to create interactive, personalized, and collaborative learning environments using tools such as Learning Management Systems (LMS), virtual labs, and online simulations. AI technologies further enhance the learning experience through intelligent tutoring systems, adaptive assessments, and data-driven insights that support learner-centered education. The integration of these technologies in EET fosters innovation, improves learning outcomes, and equips students with industry-relevant skills required for the digital economy. However, challenges such as inadequate infrastructure, limited teacher capacity, and ethical concerns about AI adoption must be addressed to ensure effective implementation. The study emphasizes the need for policy reforms, continuous professional development, and investment in digital infrastructure. By leveraging digital tools and AI, EET education can be transformed to meet 21st-century demands, drive industrialization, and contribute meaningfully to national and global economic growth. The paper concludes that technology-enhanced EET education is not only essential but imperative for achieving inclusive and sustainable economic progress.

Introduction

Electrical and electronics technology (EET) plays a pivotal role in economic development, influencing almost every sector of modern economies. It underpins innovation, productivity, industrialization, and globalization. It is central to the automation and modernization of manufacturing processes. The integration of robotics, programmable logic controllers (PLCs), and electronic sensors has significantly enhanced productivity and efficiency. According to the World Bank (2020), countries that invest in technological infrastructure, particularly in manufacturing electronics, experience faster growth in GDP and employment. Countries like China and South Korea, the electronics manufacturing sector has driven industrialization and export-led growth (OECD, 2021).

The EET sector creates both direct and indirect employment opportunities. From technicians to engineers, and from assembly workers to software developers, it stimulates a broad skills

base in the economy. The International Labour Organization (ILO, 2019) notes that the electronics industry is among the top sectors for high-skilled job creation in emerging economies. Similarly, Electricity and electronics are integral to modern infrastructure; power grids, telecommunications, transportation systems, and smart cities all depend on robust EET systems. The International Energy Agency (IEA, 2021) reports that electrification is a core strategy for achieving sustainable economic development, especially in rural and underdeveloped regions. Electrification in Sub-Saharan Africa has directly improved productivity in agriculture, small businesses, and education (World Bank, 2020).

Suffice to note that Electrical and electronics technology is indispensable to modern economic development. It fosters industrialization, innovation, employment, and connectivity, all of which are vital for sustainable and inclusive growth. The teaching of learning of electrical/electronics technology for national growth has become imperative. According to Bashi, Asukwo, Ibanga, and Amusa (2023) investment into these aspect of education through the use of digital skills and artificial intelligence will foster sustainability of electrical/electronics technology for economic development.

The ability to effectively use digital tools and platforms in education are becoming increasingly essential in modern education. They shape how educators teach and how students learn, bridging gaps in access, personalization, and engagement. Digital skills empower educators to design innovative and interactive learning experiences. Tools such as Learning Management Systems (LMS), video conferencing platforms, digital assessment tools, and simulations enhance lesson delivery and classroom management. Mishra and Koehler's (2006) observed that *Technological Pedagogical Content Knowledge (TPACK)* framework highlights the synergy between technology, pedagogy, and content knowledge as essential for effective digital teaching. A teacher proficient in digital tools can use platforms like Google Classroom or Moodle to share resources, give timely feedback, and facilitate collaborative learning. Similarly, OECD (2021), states that digital skills among teachers correlate with higher student motivation and improved classroom interaction. Digital platforms such as interactive quizzes (Kahoot, Quizizz), gamified learning (Duolingo), and multimedia content increase student engagement and motivation. Digital skills themselves are crucial 21st-century competencies, and teachers play a key role in modeling and teaching them. Skills such as information literacy, online collaboration, and digital communication are essential for student success in the digital economy. Consequently, The European Commission's *Digital Competence Framework for Educators (DigCompEdu)* (Redecker, 2017) identifies digital skills as essential

Artificial Intelligence (AI) on the other hand is reshaping the educational landscape, offering new ways to personalize learning, automate teaching tasks, and improve learning outcomes. AI-powered platforms use data analytics and machine learning to tailor instruction to individual learner needs, preferences, and pace—supporting differentiated and adaptive learning. Luckin, Holmes, Griffiths, and Forcier, (2016) emphasize that AI systems can personalize content delivery and feedback, helping students master topics at their own speed. Similarly, AI-based Intelligent Tutoring Systems simulate one-on-one human tutoring by providing immediate and customized feedback and guidance among other benefits.

An Overview of Digital Skills and Artificial Intelligence in Education

In the 21st century, digital transformation has profoundly reshaped the educational landscape. Among the key developments are the integration of digital skills and artificial intelligence (AI) into pedagogy and learning environments. These innovations have not only changed how content is delivered but also redefined the roles of educators and learners, necessitating a reevaluation of curriculum frameworks, instructional strategies, and educational outcomes.

Digital skills refer to the abilities required to use digital devices, communication applications, and networks to access and manage information effectively. In the context of education,

digital skills include basic competencies such as typing and internet browsing, as well as advanced proficiencies in data literacy, online collaboration, and the ethical use of digital content van Laar, van Deursen, van Dijk, and de Haan (2017) The European Commission (2020) classifies digital competence as one of the key competencies for lifelong learning, emphasizing its role in employment, personal development, and active citizenship. In education, students equipped with digital skills can access richer learning resources, participate in online learning communities, and become more autonomous learners. Teachers, likewise, can utilize digital tools to enhance instruction, track student progress, and differentiate content. Digital skills are also essential for addressing digital equity, especially in contexts where access to technology is uneven. According to the OECD (2021), disparities in digital skills among students from different socio-economic backgrounds can exacerbate educational inequalities, particularly in hybrid and online learning environments.

On the other hand, Artificial Intelligence in Education encompasses the use of machine learning algorithms, natural language processing, and intelligent tutoring systems to support educational processes. According to Luckin, et al (2016) AI can personalize learning experiences, automate assessment, and provide real-time feedback, contributing to more effective and efficient instruction. AI applications in education fall into several categories of: Intelligent Tutoring Systems: adaptively guide students through content, offering personalized feedback based on performance data (Koedinger and Corbett, 2006); Automated Assessment Tools: automatically grade essays, quizzes, and even code submissions, saving educators time and offering immediate responses to learners (Balfour, 2013); Learning Analytics: monitor student engagement and performance, helping educators intervene early when students are at risk of falling behind (Siemens and Long, 2011); tailor questions and lessons to individual learners' needs, optimizing the learning curve (Holmes *et al.*, 2019) and Administrative Support: streamline administrative tasks such as scheduling, resource allocation, and student support services.

The intersection of digital skills and AI is particularly relevant as AI tools often require a baseline level of digital competence to be effectively used. For instance, navigating an AI-powered learning platform necessitates familiarity with user interfaces, data privacy considerations, and online communication norms. Furthermore, Tuomi (2018) stated that teaching AI literacy itself is becoming a key component of digital education, as students are not only users but future developers or evaluators of AI systems. Educators play a crucial role in this synergy. Professional development initiatives aimed at enhancing teachers' digital skills are essential for effective AI adoption. Similarly, educators with higher levels of digital competence are more likely to integrate AI tools effectively into their teaching practice (Redecker, 2017).

Despite the promise of digital skills and AI, their implementation in education is not without challenges; Digital Divide: access to technology and digital literacy remains uneven across regions and socio-economic groups. Robinson, Cotten, Ono, Quan-Haase, Mesch, Chen, ... and Stern (2015) stated that without equitable access, AI in education may reinforce existing inequalities rather than mitigate them; Data Privacy and Ethics: AI systems often require large amounts of student data. This raises questions about consent, data security, and algorithmic bias (Williamson and Piattoeva, 2022). Educators and institutions must ensure compliance with ethical standards and data protection regulations while utilizing AI and digital tools; Over-Reliance on Technology: while AI can enhance education, over-reliance on automated systems may reduce opportunities for critical thinking and interpersonal learning. Selwyn (2019) states that human educators bring contextual understanding, empathy, and moral guidance that AI cannot replicate; Teacher Readiness and Resistance: adoption of AI requires significant changes in teaching practices and attitudes. Some educators may resist AI

integration due to lack of familiarity, perceived loss of autonomy, or skepticism about AI's pedagogical value (Howard, Tondeur, Ma, and Yang, 2021).

Digital skills and artificial intelligence are reshaping education, offering transformative opportunities for personalized learning, efficient administration, and enhanced engagement. However, their successful integration requires more than technological investment—it demands a strategic focus on skill development, ethical use, and educational equity. By fostering both digital competence and AI literacy, educational systems can prepare learners not only to thrive in the digital age but to shape it responsibly.

To maximize the benefits of digital skills and AI in education, several strategic approaches are required, prominent among them are; digital and AI literacy should be embedded in curricula at all levels, ensuring students are prepared for a technologically advanced society; continuous teacher training in digital and AI competencies is critical. Initiatives should be context-specific, practical, and aligned with pedagogical goals; National education policies should address equity and inclusion, ensuring access to digital tools and AI resources for all students; clear ethical guidelines must be developed for the use of AI in educational settings, including principles of transparency, accountability, and fairness; collaborative Research: Ongoing interdisciplinary research involving educators, technologists, policymakers, and learners is vital to assess the impact of AI and refine its educational applications. (OECD, 2021; Twining, Broadie, Cook, Ford, Morris, Twiner and Underwood, 2017)

Utilization of Digital Skills for Teaching and Learning

The integration of digital skills into teaching and learning has transformed educational landscapes across the globe. Digital skills, broadly defined as the ability to use information and communication technologies (ICT) effectively (OECD, 2021), are now essential for both educators and learners. Their utilization supports pedagogical innovation, enhances learner engagement, and facilitates access to vast resources and collaborative opportunities.

In teaching, digital skills empower educators to design and deliver content in more dynamic and interactive formats. For instance, learning management systems (LMS) such as Moodle or Canvas enable teachers to organize course materials, administer assessments, and communicate with students efficiently (Almpanis, 2015). Digital tools like interactive whiteboards, educational apps, and multimedia content not only make learning more engaging but also cater to diverse learning styles. Moreover, data analytics tools help educators monitor student progress and provide timely interventions, supporting a more personalized learning experience (Ifenthaler and Yau, 2020).

On the learners' side, digital skills are critical for navigating and leveraging online learning environments. Students use digital platforms to access academic resources, participate in discussions, and complete assignments. More importantly, they develop critical 21st-century competencies such as information literacy, problem-solving, and collaboration (Voogt, Erstad, Dede, and Mishra (2015). The COVID-19 pandemic underscored the necessity of digital skills, as education systems worldwide pivoted to remote learning. In this context, digital competencies became not just beneficial, but indispensable for educational continuity (Bozkurt and Sharma, 2020).

Furthermore, the use of digital skills in education supports inclusive learning. Assistive technologies can help students with disabilities access learning materials and participate fully in classroom activities. Similarly, digital platforms break down geographical and socioeconomic barriers, making quality education more accessible to learners in remote or under-resourced areas (UNESCO, 2022).

Similarly, digital assessment and evaluation methods have become integral to modern teaching, enabling more flexible, scalable, and data-driven approaches to measuring student learning. These methods encompass a range of tools and technologies, from online quizzes

and e-portfolios to AI-powered feedback systems and learning analytics dashboards (Redecker and Johannessen, 2013).

One key advantage of digital assessment is its potential for formative feedback. Tools such as automated quizzes and adaptive testing platforms allow immediate, individualized responses that help students monitor their progress and guide learning (Nicol, 2009). Summative assessments are also increasingly conducted through Learning Management Systems (LMS), which streamline grading and data collection.

Moreover, digital assessments support diverse forms of evaluation, including peer assessment, multimedia presentations, and simulations, thus promoting higher-order thinking and creativity (Gikandi *et al.,* 2011). Learning analytics further enable educators to track performance trends and identify at-risk students, enhancing pedagogical decision-making. Even though ensuring assessment validity, academic integrity, and digital equity. Effective implementation requires training for educators and robust infrastructure (Nguyen *et al.,* 2017). Digital assessment methods offer significant opportunities for enriching teaching and learning but must be applied thoughtfully to ensure fairness and effectiveness.

Despite the benefits, challenges remain. The digital divide continues to affect equitable access to digital tools and internet connectivity, especially in low-income regions. Moreover, teachers often require ongoing professional development to keep pace with technological advancements and integrate digital tools effectively into pedagogy (Tondeur, van Braak, Ertmer, and Ottenbreit-Leftwich, 2017). Institutional support, infrastructure investment, and policy frameworks are crucial for addressing these issues and fostering the widespread adoption of digital skills in education.

The Role of Artificial Intelligence in Enhancing Teaching and Learning

Artificial Intelligence (AI) ha\s emerged as a transformative force in education, offering new possibilities for teaching and learning through intelligent systems capable of mimicking cognitive functions such as learning, reasoning, and problem-solving. The integration of AI into education is reshaping pedagogical approaches, personalizing learning experiences, and optimizing administrative processes. One of the most prominent roles of AI in education is its ability to support personalized learning. AI-powered systems can adapt content to meet individual student needs, pacing, and learning styles. Intelligent Tutoring Systems (ITS), such as Carnegie Learning, use data from student interactions to tailor instruction in real time, improving learner outcomes and engagement (Pane *et al.,* 2015). These systems analyze student performance data to identify knowledge gaps, allowing for targeted interventions and support Luckin, *et al,* 2016).

AI also enhances assessment processes. Automated grading systems can evaluate multiple-choice and short-answer responses efficiently, providing immediate feedback to learners. More advanced natural language processing (NLP) technologies are being developed to assess essays and open-ended responses with increasing accuracy (Shermis and Burstein, 2013). This automation not only reduces the workload for educators but also supports formative assessment by delivering timely and individualized feedback.

In teaching, AI can act as a virtual assistant, supporting educators in curriculum design, resource curation, and classroom management. For example, AI tools like IBM Watson Education assist teachers in identifying suitable learning materials based on student performance and curriculum standards (Holmes *et al.,* 2019). Furthermore, AI-driven analytics can provide insights into class performance trends, helping educators make data-informed decisions about instructional strategies and interventions.

AI also facilitates inclusive education. Adaptive technologies powered by AI, such as speech-to-text applications and real-time translation tools, support learners with disabilities and language barriers, enhancing accessibility and participation. These tools contribute to more equitable learning environments by accommodating diverse learner needs.

In laboratory settings, AI applications such as virtual labs and simulations enable students to experiment with electronic circuits and devices without the constraints of physical components (Alimisis, 2013). AI-driven platforms like MATLAB with machine learning toolboxes also support data analysis and predictive modeling tasks, which are essential skills in modern electronics engineering. Moreover, AI facilitates automated assessment and grading of practical tasks, enabling instructors to track student performance efficiently. Learning analytics derived from AI can also help identify misconceptions or skill gaps early, allowing for timely intervention (Zawacki-Richter *et al.*, 2019). Overall, AI enhances both theoretical and practical dimensions of electrical/electronics education, preparing students for emerging industry demands driven by automation and intelligent systems.

Despite its benefits, the use of AI in education raises several ethical and practical challenges. Concerns about data privacy, algorithmic bias, and transparency must be addressed to ensure responsible and equitable use of AI (Williamson & Eynon, 2020). Moreover, educators require professional development to understand and effectively integrate AI technologies into their practice. Without adequate training and support, there is a risk of misusing or underutilizing these tools.

Economic Benefits of Digital Skills and AI in Electrical and Electronics Technology Education

Electrical and electronics technology (EET) plays a pivotal role in economic development, influencing almost every sector of modern economies. It underpins innovation, productivity, industrialization, and globalization. it is central to the automation and modernization of manufacturing processes. The integration of robotics, programmable logic controllers (PLCs), and electronic sensors has significantly enhanced productivity and efficiency. According to the World Bank (2020)**,** countries that invest in technological infrastructure, particularly in manufacturing electronics, experience faster growth in GDP and employment. Similarly, EET is the foundation of innovations in information and communication technologies (ICT), renewable energy, artificial intelligence, and smart infrastructure, which are key drivers of economic transformation.

According to International Labour Organization (ILO, 2019) EET sector creates both direct and indirect employment opportunities. From technicians to engineers, and from assembly workers to software developers, it stimulates a broad skills base in the economy. Its notes that the electronics industry is among the top sectors for high-skilled job creation in emerging economies for example the India's electronics sector, projected to reach $300 billion by 2026, is expected to create millions of jobs (MeitY, Government of India, 2022). EET sector also facilitates the development of the digital economy through broadband infrastructure, mobile communication, cloud computing, and fintech—enhancing transparency, efficiency, and service delivery, UNCTAD (2022) notes that Estonia's e-governance model, enabled by advanced ICT and electronics, has significantly improved its public service efficiency and international competitiveness. It is therefore imperative to state that Electrical and electronics technology is indispensable to modern economic development. It fosters industrialization, innovation, employment, and connectivity, all of which are vital for sustainable and inclusive growth

Challenges of Using Digital Skills and AI in Teaching and Learning of Electrical/Electronics Technology

The integration of digital skills and artificial intelligence (AI) in the teaching and learning of Electrical/Electronics Technology (EET) offers significant potential for improved learning outcomes, but it also presents various challenges.

1. Digital Divide and Access Inequality: One major challenge is unequal access to digital infrastructure. Many students and institutions, particularly in developing countries, lack the necessary hardware, stable internet connectivity, and access to software tools required for AI-

integrated learning platforms (Almpanis, 2015). This disparity hinders equitable implementation of digital and AI-based education in EET.

2. Lack of Technical Expertise: Both instructors and students often lack sufficient training in the use of advanced digital tools and AI systems. According to UNESCO (2021) Electrical/Electronics educators may be well-versed in technical content but not adequately trained in AI-based pedagogies or digital literacy. This knowledge gap limits the effectiveness of technology integration.

3. High Cost of Implementation: The deployment of AI systems, simulation software (e.g., MATLAB/Simulink, Multisim), virtual labs, and smart classrooms involves high costs. Many polytechnics and universities lack the budget to acquire, maintain, and regularly update such technologies (Fomunyam, 2020).

4. Curriculum Rigidity and Lag: According to Chukwuemeka, Ezeh, and Uzoechina (2023) the rapid advancement of AI and digital tools is often outpaced by curriculum development. Most EET curricula are not updated frequently to incorporate emerging AI technologies, resulting in a disconnect between academic training and industry requirements.

5. Pedagogical Constraints: AI tools are sometimes limited in their ability to replicate the hands-on experience crucial for EET learning, such as soldering, circuit testing, and physical troubleshooting. Over-reliance on digital simulations may undermine practical skill development (Sani *et al.,* 2022).

8. Resistance to Change: There is institutional and cultural resistance from some educators who are skeptical of the reliability of AI tools or concerned about job displacement. This mindset can slow the adoption and effective use of digital innovations (OECD, 2021).

Way Forward to the Challenges of Using Digital Skills and AI in EET Education

To fully harness the potential of digital skills and AI in Electrical/Electronics Technology education, a multi-faceted and strategic approach must be adopted. The following measures offer a sustainable way forward:

1. Infrastructure Development and Digital Inclusion: Addressing the digital divide requires significant investment in infrastructure. Governments and institutions should collaborate with private sector partners to expand internet access, provide affordable devices, and equip laboratories with necessary digital and AI-enabled tools. Initiatives like Nigeria's National Broadband Plan and the TETFund interventions are steps in the right direction

2. Capacity Building for Educators and Students: Comprehensive digital literacy and AI training should be integrated into teacher development programs. Upskilling educators in AI-driven pedagogies, simulations, and educational technologies will boost confidence and competence. This also includes embedding AI and digital skill modules in the undergraduate and TVET curriculum for future EET professionals.

3. Curriculum Reform and Industry Alignment: There is a need to revise and update the EET curriculum to incorporate current digital technologies and AI applications relevant to the discipline. Curriculum reforms should align with global trends and be co-designed with industry stakeholders to ensure practical relevance and employability.

4. Promotion of Virtual and Remote Labs: To mitigate the limitations of hands-on practical work, institutions should invest in virtual laboratories, augmented reality (AR), and remote-access platforms. These tools provide safe and flexible environments for practical skills training when physical labs are not available.

5. Policy Frameworks and Ethical Guidelines: Establishing clear national policies and institutional frameworks for ethical use of AI in education is critical. These should address data protection, transparency, algorithmic fairness, and student privacy. The Nigerian Data Protection Act (NDPA) of 2023 can guide these implementations.

6. Research and Innovation Support: Government agencies and higher education institutions should increase funding for research into AI-based instructional design, adaptive

learning, and automation tools tailored for EET. Collaboration with global edtech innovators and academic exchanges will also enhance local capacity.

7. Cultural and Organizational Change: Stakeholders must foster a culture of innovation, experimentation, and openness to change. Leadership support and reward systems for adopting digital innovations will help overcome resistance and drive system-wide adoption.

Conclusion

Electrical and Electronics Technology (EET) remains a cornerstone of modern economic development, driving innovation, industrialization, and inclusive growth across various sectors. It not only supports critical infrastructure such as power, telecommunications, and transportation, but also serves as a catalyst for employment and skill development in both developed and emerging economies. The strategic integration of digital skills and artificial intelligence (AI) into EET education has become increasingly vital for sustaining this momentum. Digital tools enhance teaching effectiveness and student engagement, while AI enables personalized learning and data-driven instruction. However, to fully realize these benefits, there must be deliberate investments in teacher training, technological infrastructure, and curriculum reform. As global trends move towards smart manufacturing, electrification, and digital transformation, equipping learners with competencies in EET, supported by digital and AI technologies, will be essential for national progress. Educators play a critical role in modeling these skills and fostering innovation-driven mindsets. Therefore, advancing EET education through modern digital approaches is not just a pedagogical upgrade—it is a strategic imperative for economic competitiveness, sustainability, and social advancement in the 21st century. Fostering this integration ensures that nations are prepared to meet current challenges and seize future opportunities in the global technological landscape.

References

Alimisis, D. (2013). Educational robotics: Open questions and new challenges. *Themes in Science and Technology Education, 6*(1), 63–71.

Almpanis, T. (2015). Staff development and institutional support for technology enhanced learning in UK universities. *Electronic Journal of E-Learning, 13*(5), 366–375.

Balfour, S. P. (2013). Assessing writing in MOOCs: Automated essay scoring and calibrated peer review™. *Research & Practice in Assessment, 8*, 40–48.

Bozkurt, A., & Sharma, R. C. (2020). Emergency remote teaching in a time of global crisis due to the coronavirus pandemic. *Asian Journal of Distance Education, 15*(1), 1–6.

Chukwuemeka, E. E., Ezeh, M. I., & Uzoechina, O. G. (2023). Integrating artificial intelligence into the curriculum of technical education in Nigeria: Issues and prospects. *Nigerian Journal of Technology Education, 13*(1), 45–54.

European Commission. (2020). *Digital education action plan 2021–2027*. https://education.ec.europa.eu/focus-topics/digital/digital-education-action-plan

Fomunyam, K. G. (2020). Digitising the curriculum for the Fourth Industrial Revolution: A South African higher education perspective. *Education and Information Technologies, 25*(5), 4781–4795.

Gikandi, J. W., Morrow, D., & Davis, N. E. (2011). Assessment in online learning: Validity, reliability and pedagogical implications. *Online Learning Journal, 15*(1), 1–14.

Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.

Holmes, W., Bialik, M., & Fadel, C. (2021). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.

Howard, S. K., Tondeur, J., Ma, J., & Yang, J. (2021). What to teach? Strategies for developing digital competency in pre-service teacher training. *Computers & Education, 165*, 104149.

Ifenthaler, D., & Yau, J. Y.-K. (2020). Utilising learning analytics to support study success in higher education. *Educational Technology Research and Development, 68*, 1989–2006.

International Energy Agency. (2021). *World energy outlook*.

International Labour Organization. (2019). *Skills for a greener future*.

Koedinger, K. R., & Corbett, A. T. (2006). Cognitive tutors: Technology bringing learning sciences to the classroom. In R. K. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences* (pp. 61–78). Cambridge University Press.

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence unleashed: An argument for AI in education*. Pearson Education.

MeitY, Government of India. (2022). *Electronics manufacturing: Vision 300 billion*.

Nguyen, H., Rienties, B., & Toetenel, L. (2017). Examining the design of technology-enhanced learning environments in higher education: A learning analytics perspective. *British Journal of Educational Technology, 48*(3), 1044–1058.

Nicol, D. J. (2009). Assessment for learner self-regulation: Enhancing achievement in the first year using learning technologies. *Assessment & Evaluation in Higher Education, 34*(3), 335–352.

OECD. (2019). *OECD skills outlook 2019: Thriving in a digital world*. OECD Publishing.

OECD. (2021). *21st-century readers: Developing literacy skills in a digital world*. https://doi.org/10.1787/a83d84cb-en

OECD. (2021). *AI and the future of skills, volume 1: Capabilities and assessments*. OECD Publishing.

OECD. (2021). *Productivity and innovation in the electronics industry*.

Redecker, C. (2017). *European framework for the digital competence of educators: DigCompEdu*. Publications Office of the European Union.

Redecker, C., & Johannessen, Ø. (2013). Changing assessment—Towards a new assessment paradigm using ICT. *European Journal of Education, 48*(1), 79–96.

Robinson, L., Cotten, S. R., Ono, H., Quan-Haase, A., Mesch, G., Chen, W., ... & Stern, M. J. (2015). Digital inequalities and why they matter. *Information, Communication & Society, 18*(5), 569–582.

Sani, A. A., Musa, A. A., & Muhammad, A. I. (2022). The role of virtual laboratories in the teaching of electrical engineering courses in Nigerian polytechnics. *Nigerian Journal of Electrical and Electronics Engineering Technology, 4*(1), 13–20.

Selwyn, N. (2019). *Should robots replace teachers? AI and the future of education*. Polity Press.

Shermis, M. D., & Burstein, J. (Eds.). (2013). *Handbook of automated essay evaluation: Current applications and new directions*. Routledge.

Siemens, G., & Long, P. (2011). Penetrating the fog: Analytics in learning and education. *EDUCAUSE Review, 46*(5), 30–40.

Tondeur, J., van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: A systematic review of qualitative evidence. *Educational Technology Research and Development, 65*(3), 555–575.

Tuomi, I. (2018). *The impact of artificial intelligence on learning, teaching, and education: Policies for the future*. European Commission Joint Research Centre. https://doi.org/10.2760/12297

Twining, P., Broadie, R., Cook, D., Ford, K., Morris, D., Twiner, A., & Underwood, J. (2017). *Education Technology Action Group (ETAG) final report*. Department for Education (UK).

UNCTAD. (2022). *Digital economy report*.

UNESCO. (2021). *Reimagining our futures together: A new social contract for education*. UNESCO Publishing.

UNESCO. (2022). *Technology in education: A tool on whose terms?* Global Education Monitoring Report.

van Laar, E., van Deursen, A. J., van Dijk, J. A., & de Haan, J. (2017). The relation between 21st-century skills and digital skills: A systematic literature review. *Computers in Human Behavior, 72*, 577–588.

Voogt, J., Erstad, O., Dede, C., & Mishra, P. (2015). Challenges to learning and schooling in the digital networked world of the 21st century. *Journal of Computer Assisted Learning, 31*(5), 453–469.

Williamson, B., & Eynon, R. (2020). Historical threads, missing links, and future directions in AI in education. *Learning, Media and Technology, 45*(3), 223–235.

Williamson, B., & Piattoeva, N. (2022). Education governance and datafication. *Critical Studies in Education, 63*(1), 1–15.

World Bank. (2020). *World development report: Trading for development*.

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – Where are the educators? *International Journal of Educational Technology in Higher Education, 16*(1), 1–27.

EVALUATION OF AN INTELLIGENT TUTORING SYSTEM FOR TEACHING BASIC-ELECTRONICS CONCEPTS IN TECHNICAL COLLEGES IN SOUTH-WEST, NIGERIA

AKINDELE, N. A., SOETAN, A. K.
Department of Educational Technology, Faculty of Education, University of Ilorin, Kwara State, Nigeria
Corresponding Author Email Address: akindele.na@unilorin.edu.ng GSM: 08023256607

Abstract

Intelligent Tutoring System (ITS) is a computer-based learning system that mimics the functions of a human tutor, adapting instructional content to the learner's pace. However the limited integration of ITS in technical education hinders personalized learning and student performance. This study assessed the impact of ITS on teaching Basic-Electronics in technical colleges in South-West Nigeria. The research investigated how ITS influences students' mastery and application of knowledge and skills. A quasi-experimental design, 75 students, 36 experimental and 39 control, were selected through multi-stage sampling. Data were gathered using validated and reliable instruments: BEAT (KR-20 = 0.82) and BEPAT (inter-scorer reliability = 0.96; Cronbach Alpha = 0.70–0.72). Results indicated significant gains in cognitive and psychomotor performance among ITS-taught students. The study recommended integrating ITS into the national curriculum and promoting research on adaptive learning technologies in vocational and technical education.

Keywords: Adaptive Learning, Basic-Electronics Cognitive performance,, Educational Technology Intelligent Tutoring System, , Psychomotor Skills, Technical Education, ,

Introduction

Education plays a vital role in national development by equipping learners with the knowledge, skills and attitudes necessary for social, economic and technological advancement. Among the major challenges in education is how to enhance student learning through effective instructional delivery, particularly in technical and vocational subjects that demand both theoretical knowledge and practical competence. The integration of educational technology has been widely recognized as a strategy for improving teaching and learning processes across all levels of education. A prominent innovation in this domain is the **Intelligent Tutoring System (ITS)**, which leverages artificial intelligence to offer individualized instruction tailored to learners' needs, thereby enhancing learning outcomes, especially in cognitive and psychomotor domains (Huq *et al.*, 2024).

The ITS is a computer-based learning system that mimics the functions of a human tutor by adapting instructional content to the learner's pace and understanding. It comprises four core components: the **expert model** (subject knowledge), the **student model** (learners' data and progress), the **tutoring model** (instructional decisions), and the **user interface** (interactive environment). These modules work collaboratively to diagnose student learning gaps and provide real-time, personalized feedback and scaffolding (Troussas *et al.*, 2020). This adaptability makes ITS particularly suitable for science and technical subjects such as **Basic Electronics**, requiring learners to grasp theoretical concepts and apply them in practical scenarios.

Basic Electronics, as a core trade subject in Nigerian technical colleges, encompasses the study and application of electrical and electronic principles, including circuit analysis,

modulation, signal transmission, component testing, and device maintenance. It involves both **cognitive engagement**, such as conceptual understanding and problem-solving, and **psychomotor engagement**, such as assembling, diagnosing, and repairing electronic devices. Leveraging ITS to streamline conventional methods often struggle to address dual demands due to the limited capacity for personalization and immediate feedback. In contrast, ITS offers an adaptive learning environment that facilitates both the acquisition of theoretical knowledge and the development of hands-on technical skills (Bhuttah *et al.*, 2024).

Technical colleges in Nigeria are mandated to produce skilled craftsmen and technicians capable of contributing meaningfully to national development through applied knowledge and technical competence. According to the **National Board for Technical Education (NBTE, 2018)**, technical colleges aim to provide vocational training that emphasizes both academic understanding and skill acquisition in areas such as Basic Electronics. However, many technical colleges face challenges including limited instructional resources, overcrowded classrooms, and a shortage of qualified personnel. These limitations often compromise the quality of instruction and reduce opportunities for individualized support. The deployment of ITS in such environments can address these gaps by providing consistent, high-quality instruction that adapts to the learner's pace, background knowledge, and engagement level (Conati *et al.*, 2021).

From a pedagogical perspective, ITS supports **cognitive performance** by offering concept reinforcement, immediate feedback, and scaffolded problem-solving, all of which promote meaningful learning. Cognitive performance refers to the learner's ability to acquire, retain, and apply theoretical knowledge, often measured through assessments such as written tests, assignments, and problem-solving tasks (Imam *et al.*, 2023). A learner's success in this domain is largely influenced by the quality of instructional delivery, the use of appropriate teaching methods, and the integration of feedback mechanisms. ITS improves this process by dynamically assessing learners' comprehension and presenting content that aligns with their learning needs, ensuring that learners progress at an optimal pace and with greater conceptual clarity (Wang, 2019).

In terms of **psychomotor performance**, ITS offers interactive simulations, guided practice tasks, and problem-solving modules that replicate real-world electronic operations. Psychomotor performance involves the learner's physical ability to manipulate tools, instruments and equipment to complete practical tasks. According to Amorim et al. (2024), this domain focuses on the accurate and efficient execution of manual tasks, often evaluated through performance-based assessments. ITS can facilitate this process by simulating practical scenarios where learners receive guided instructions and corrective feedback, enhancing their technical dexterity and precision. Through these features, ITS not only supports skill development but also boosts learners' confidence in performing hands-on tasks independently.

Research has shown that instructional systems which integrate AI-driven feedback loops and personalized content delivery significantly improve learners' cognitive and psychomotor outcomes. As Chou et al. (2022) explain, such systems create active learning environments where students engage with content more deeply and persistently. This is particularly important in technical education, where mastery of content often requires repeated practice and timely correction. ITS also allows for the monitoring of learners' progression through analytics and performance tracking, enabling instructors to intervene effectively when necessary and modify learning trajectories accordingly. The potential of ITS in transforming instruction in Basic Electronics education in Nigeria aligns with global best practices where technology is leveraged to enhance learning outcomes in technical and vocational education. In countries such as Australia, the UK, and Finland, ITS has been effectively deployed across multiple disciplines to improve both theoretical understanding and

skill proficiency.

In Nigeria, there remains a significant gap in the adoption and evaluation of ITS in technical colleges. As Adeoye et al. (2024) suggest, instructional technology must be contextually evaluated to ensure alignment with educational goals, learner needs, and institutional capacity. In this case, evaluating ITS within the Nigerian technical education system will inform policy, curriculum development, and the broader adoption of digital instructional strategies in vocational education. The goal is not only to enhance students' academic performance but also to prepare them more effectively for the demands of modern electronic industries.

Focusing on **cognitive and psychomotor performance**, this study seeks to assess the practical value of ITS in improving instructional quality, student engagement,and skill acquisition. The outcome will contribute to the growing body of knowledge on technology-enhanced learning in technical and vocational education and support informed decisions on instructional innovation in Nigeria's educational sector. Therefore, this study investigates the extent to which ITS can be utilized to improve the **cognitive and psychomotor performance** of students in the Basic Electronics programme in technical colleges in South-West Nigeria.

Statement of the Problem

Education in the 21st century has shifted from teacher-centered to learner-centered approaches, yet many Basic-Electronics teachers in Nigerian technical colleges still rely on conventional "talk-and-chalk" methods (Muganga & Ssenkusu, 2019). This conventional approach hinders students' cognitive development, practical skills, and retention. In South-West Nigeria, rote memorization dominates instruction, leading to disengagement, truancy, and poor academic performance (Oteyola, 2022). The gap between classroom learning and real-world applications further weakens students' preparedness for careers in Electronics Engineering.

Basic-Electronics is crucial for advancements in telecommunications and ICT, yet students continue to underperform due to ineffective teaching strategies and inadequate teaching difficult topics (Okolie, *et al.,* 2020). Despite the National Policy on Education's goal of producing self-reliant craftsmen (FRN, 2014), technical college graduates often lack the skills needed for employment, contributing to Nigeria's reliance on foreign specialists (Okolie *et al.*, 2020). Although investments in Nigeria's education sector have been significant, science and technology subjects remain challenging, especially basic-electronics. Intelligent Tutoring Systems (ITS) offer a potential solution by providing personalized, interactive, and self-paced learning experiences (Abdulrahman & Soetan, 2018).

However, in accordance with the literature reports most ITS software is foreign-made, limiting its adoption in Nigeria's technical colleges. The absence of locally evaluated ITS tools further hinders the integration into Basic-Electronics education. The consequential effect of which amounted to denying the students in the technical skills needed to function effectively in the increasingly technologically oriented society. But, there is an emphasis on the use of ICT to meet the challenges of modern era, especially in Nigeria with her vision of being one of the twentieth biggest economies in the world by the year 2030.

More importantly, the vital requirements of workplaces from employees are higher order thinking, skill for lifelong learning and self-reliance (International Labour Oorganization (ILO), Sustainable Development Goal (SDG4) and United Nations Education and Scientific Organisation (UNESCO, 2022). To address these challenges, this study aims to bridge educational gaps, enhance technical students' cognitive and psychomotor competencies, and promote self-reliance by evaluating a Basic-Electronics Intelligent Tutoring System for the use in teaching and learning Basic-Electronics in technical colleges in South-West Nigeria.

Purpose of the Study

1. To determine the effect of Intelligent Tutoring System on the cognitive achievement of students in Basic-Electronics programme in technical college.
2. To assess the effect of Intelligent Tutoring System on the psychomotor achievement of students in Basic-Electronics programme in technical college.

Research Questions

1. What is the effect of Intelligent Tutoring System on students' Cognitive performance in Basic-Electronics programme in technical college?
2. What is the effect of Intelligent Tutoring System on students' psychomotor performance in the Basic-Electronics programme in technical college?

Research Hypotheses

Ho_1: There is no significant difference between the mean scores of Experimental group and Control group in the Cognitive performance of students in Basic-electronics programme in technical college.

Ho_2: There is no significant difference between the mean scores of Experimental group and Control group in the Psychomotor performance of students in Basic-electronics programme in technical college.

Significance of the Study

The result of the study would be of great benefit to the following stakeholders: the National Board for Technical Education (NBTE), curriculum designers, educational technologists, students, teachers, industries, parents, and future researchers. The findings would provide **National Board for Technical Education** (NBTE) with empirical data on the effectiveness of Intelligent Tutoring Systems (ITS) in improving instructional delivery. This insight would guide policy formulation and national strategies for integrating ITS in technical education, fostering innovation and quality assurance in teaching and learning processes. The study would offer valuable information to curriculum designers on how ITS can be embedded effectively within existing and future curricula. It will highlight key areas where digital intelligence can complement conventional instructional approaches, ensuring that curricula remain relevant to current technological advancements and industry demands.

Educational technologists could benefit by gaining a clearer understanding of the practical applications and limitations of ITS in technical college settings. The study will inform the development of more effective tools, platforms, and instructional resources that align with teachers' needs and students' learning styles. For students, the study promises improved learning experiences through personalized instruction, adaptive learning paths, and immediate feedback enabled by ITS. This can enhance their engagement, understanding of complex technical subjects, and overall academic achievement.

Teachers stand to gain significantly from capacity-building initiatives informed by the study's outcomes. Enhanced knowledge and skills in utilizing ITS might empower teachers to deliver more effective, interactive, and differentiated instruction, ultimately improving classroom dynamics and learning outcomes. Industries would benefit indirectly through the production of more competent and technologically adept graduates. As technical colleges adopt ITS-enhanced teaching methods, students will develop skills that are more aligned with modern industry requirements, thereby improving workforce readiness.

Parents would gain from the improved academic performance and employability of their children. The use of ITS is expected to foster greater student motivation and achievement, which can lead to better career prospects and social mobility, aligning with parents' aspirations for their children's futures. Future researchers could find this study a valuable reference point for further investigations into ITS in education. It will contribute to the growing body of literature on educational technology and serve as a basis for more nuanced studies exploring different aspects of ITS integration in various educational contexts.

Methodology

A quasi-experimental research design was adopted, specifically a pre-test, post-test, non-equivalent control group design combined with descriptive research design. The study was conducted in two technical colleges in Lagos State, with a population of 2205 respondents comprising 143 teachers, 1749 NTC II Basic-Electronics students, 200 Educational Technology experts and 113 Instructional Design experts. A multi-stage sampling technique was used: first, purposive sampling was applied to select Lagos State out of six states in South-West Nigeria, then simple random sampling was used to select two technical colleges out of six technical colleges in Lagos State, balloting sampling technique was used to assign students to treatment groups, with 36 students in the experimental group and 39 students in the control group. The instruments for data collection were the Basic Electronics Achievement Test (BEAT),

Basic Electronics Psychomotor Achievement Test (BEPAT), expert validation forms, and cognitive/psychomotor pre-test/post-test, all validated by experts in instructional design, educational technology and basic electronics teaching. Reliability was established using Kuder-Richardson 20 (KR-20) for BEAT (0.82), inter-scorer reliability for BEPAT (0.96), and Cronbach Alpha for expert validation instruments (0.70-0.72), confirming strong internal consistency. Data collection lasted eight weeks of treatment with a two-week delayed retention test. Data were analyzed using Mean scores and standard deviation for research` questions and ANCOVA at 0.05 significance level for hypotheses testing.

Result

Research Question One: What is the effect of Intelligent Tutoring System on students' Cognitive performance in Basic-Electronics programme in technical college? The results showing the extent to which the Intelligent Tutoring System influence students' Cognitive performance in Basic-Electronics programme in technical college is presented in Table 1.

Table 1: Summary of Statistics of Pre-test and Post-test Mean Cognitive Performance Scores of Students Taught Basic-Electronics using Intelligent Tutoring System and Conventional Teaching Method

Groups		Pre-test		Post-test		
	N	Mean	SD	Mean	SD	Mean Gain
Experimental Group	36	26.75	1.94	80.03	1.46	53.28
Control Group	39	25.33	.70	68.85	1.69	43.52

The extent to which the Intelligent Tutoring System influences students' cognitive performance in the Basic-Electronics programme in technical college is presented in Table 1. The result shows that the experimental group, which was taught using the Intelligent Tutoring System, had a pre-test mean score of 26.75 (SD = 1.94) and a post-test mean score of 80.03 (SD = 1.46), resulting in a mean gain of 53.28. In contrast, the control group taught using the conventional teaching method had a pre-test mean score of 25.33 (SD = 0.70) and a post-test mean score of 68.85 (SD = 1.69), resulting in a mean gain of 43.52. This indicated that students taught Basic-Electronics with the Intelligent Tutoring System achieved a higher improvement in cognitive performance compared to those taught using the conventional method.

Research Question Two: What is the effect of Intelligent Tutoring System on students' psychomotor performance in the Basic-Electronics programme in technical college? The results showing the degree to which using an Intelligent Tutoring System affect students' psychomotor performance in the Basic-Electronics programme in technical college is presented in Table 2.

Table 2: Summary of Statistics of Pre-test and Post-test Mean Psychomotor Performance Scores of Students Taught Basic-Electronics using Intelligent Tutoring System and Conventional Teaching Method

Groups		Pre-test		Post-test		
	N	Mean	SD	Mean	SD	Mean Gain
Experimental Group	36	35.33	1.28	83.28	1.08	47.95
Control Group	39	34.43	1.60	75.74	1.46	41.31

Table 2 presents the degree to which using an Intelligent Tutoring System affects students' psychomotor performance in the Basic-Electronics programme in technical college. The result shows that the experimental group, taught using the Intelligent Tutoring System, had a pre-test mean score of 35.33 (SD = 1.28) and a post-test mean score of 83.28 (SD = 1.08), resulting in a mean gain of 47.95. Meanwhile, the control group, taught using the conventional teaching method, had a pre-test mean score of 34.43 (SD = 1.60) and a post-test mean score of 75.74 (SD = 1.46), with a mean gain of 41.31. This indicated that the use of the Intelligent Tutoring System had a greater positive effect on students' psychomotor performance in Basic-Electronics compared to the conventional teaching method.

Hypothesis One:

H_{O1}: There is no significant difference between the mean scores of Experimental group and Control group in the Cognitive performance of students in Basic-electronics programme in technical college. Results for testing hypothesis one is contained in Table 3.

Table 3: Analysis of Covariance for the test of significant difference between the mean scores of Experimental group and Control group in the Cognitive performance of students in Basic-electronics programme in technical college

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2341.449[a]	2	1170.725	460.268	.000
Intercept	1351.245	1	1351.245	531.239	.000
Pretest	.912	1	.912	.358	.551
Group	2304.627	1	2304.627	906.058	.000*
Error	183.137	72	2.544		
Total	415596.000	75			
Corrected Total	2524.587	74			

a. R Squared = .927 (Adjusted R Squared = .925)

Table 3 presents the results for the test of significant difference between the mean scores of the experimental group and the control group in the cognitive performance of students in the Basic-Electronics programme in technical college. The result shows an F-value of 906.058 and a p-value of .000 ($p < 0.05$), indicating a statistically significant difference between the two groups. This means that students taught using the Intelligent Tutoring System performed significantly better in cognitive tasks than those taught using the conventional method. Therefore, the null hypothesis is rejected, confirming that the Intelligent Tutoring System had a significant positive effect on students' psychomotor performance in the Basic-Electronics programme.

Hypothesis Two

H_{O1}: There is no significant difference between the mean scores of Experimental group and Control group in the Psychomotor performance of students in Basic-electronics programme in technical college. Results for testing hypothesis two is contained in Table 4.

Table 4: Analysis of Covariance for the test of significant difference between the mean scores of Experimental group and Control group in the Psychomotor performance of students in Basic-electronics programme in technical college.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1063.877[a]	2	531.938	315.475	.000
Intercept	896.271	1	896.271	531.548	.000

Pretest	1.255	1	1.255	.744	.391
Group	1058.685	1	1058.685	627.870	.000*
Error	121.403	72	1.686		
Total	473536.000	75			
Corrected Total	1185.280	74			

a. R Squared = .898 (Adjusted R Squared = .895)

Table 4 presents the results for the test of significant difference between the mean scores of the experimental group and the control group in the psychomotor performance of students in the Basic-Electronics programme in technical college. The result shows an F-value of 627.870 and a p-value of .000 ($p < 0.05$), indicating a statistically significant difference between the two groups. This means that students taught using the Intelligent Tutoring System outperformed those taught using the conventional method in psychomotor tasks. Therefore, the null hypothesis is rejected, confirming that the Intelligent Tutoring System had a significant positive effect on students' psychomotor performance in the Basic-Electronics programme.

Findings and Discussion

Findings showed that students exposed to the Intelligent Tutoring System (ITS) in Basic-Electronics recorded significantly higher cognitive performance than those taught using conventional methods, as confirmed by a statistically significant difference in their mean scores. The ITS offered personalized, interactive, and adaptive learning with real-time feedback, which enhanced understanding and application of concepts. This aligns with Arıcı and Karacı (2018), who found better academic performance among students using a web-based ITS. Similarly, Chien et al. (2008) reported improved achievement in algebra through ITS use, while Çakır (2019) linked ITS to increased motivation and academic success. Cerezo et al. (2020) observed enhanced cognitive engagement in learners with disabilities using ITS in online education. Pandey et al. (2024) also confirmed, through meta-analysis, the positive impact of ITS across various disciplines.

However, contrary views by Dascalu et al. (2022) and Neagu (2022) showed ITS was less effective for psychomotor skills due to limitations in simulating real-world actions. This contrast supports the present study's focus on cognitive learning, where virtual tools and simulations were better suited. The ITS's ability to offer individualized pacing, instant feedback, and concept repetition may have driven the observed improvement. Clément et al. (2024) also highlighted the value of learner autonomy and machine learning in enhancing motivation and outcomes, reinforcing the current findings.

Findings indicated that students taught Basic-Electronics using an Intelligent Tutoring System (ITS) significantly outperformed those taught through conventional methods in psychomotor tasks, with statistical evidence supporting this improvement. The ITS enabled students to visualize, simulate, and repeatedly practice technical skills through interactive modules, enhancing kinaesthetic learning. This aligns with Neagu (2022) and Dascalu et al. (2022), who recognized ITS potential in psychomotor training, despite noting challenges in capturing fine motor actions. The current study contrasts with their concerns by demonstrating successful psychomotor enhancement, likely due to the ITS's tailored use of virtual labs and guided simulations. Clément et al. (2024) supported the role of adaptive machine learning and learner autonomy in improving motivation and performance. While prior research like Arıcı and Karacı (2018), Çakır (2019), and Oteyola (2022) focused on cognitive gains, this study expands the discourse by showing ITS effectiveness in skill-based, hands-on learning. The ITS's provision for safe, repeatable practice helped build procedural fluency and muscle memory without equipment risks. Features such as self-paced learning, step revisitation, and immediate feedback contributed to improved psychomotor outcomes. Pandey et al. (2024)

affirmed that these elements are central to effective ITS-driven learning across domains, further validating the findings.

Recommendations

Curriculum developers at National Boars for Technical Education should integrate BEITS into the national TVET framework by aligning its content with existing learning objectives through collaboration with subject experts.

Conclusion

The study highlighted the evaluation of a BEITS aimed at enhancing instructional delivery and learning outcomes in technical colleges. Based on the findings of the study, it is concluded that the Basic-Electronics Intelligent Tutoring System is an effective and reliable instructional tool that enhances both cognitive and psychomotor learning outcomes in technical college students, and its integration into the technical education curriculum is strongly justified.

References

Abdulrahman, M. R., & Soetan, A. K. (2018). Lecturers' Perceived Ease of Use of Mobile Devices for Teaching Undergraduates, Kwara State, Nigeria. *International Journal for Innovative Technology Integration in Education, 1(1), 1 – 14.*

Adeoye, M. A., Wirawan, K. A. S. I., Pradnyani, M. S. S., & Septiarini, N. I. (2024). Revolutionizing Education: Unleashing the Power of the ADDIE Model for Effective Teaching and Learning. *JPI (Jurnal Pendidikan Indonesia), 13*(1), 202-209.

Amorim, N., Marques, A., & Santos, S. (2024). Beyond the Classroom: Investigating the Relationship between Psychomotor Development and Academic Achievement in 4–12-Year-Olds. *Children*, *11*(8), 973.

Arıcı, N., & Karacı, A. (2018). The Effect of a Web-Based Intelligent Tutoring System on Academic Achievement and Retention in an Electronic Spreadsheet Course. *International of Computer Applications, 181*(16), 35-41.

Bhuttah, T. M., Xusheng, Q., Abid, M. N., & Sharma, S. (2024). Enhancing Student Critical Thinking and Learning Outcomes through Innovative Pedagogical Approaches in Higher Education: The Mediating Role of Inclusive Leadership. *Scientific Reports*, *14*(1), 24362.

Çakır, R. (2019). The effect of a web-based intelligent tutoring system on students' achievement and motivation. *International Journal of Education and Development using Information and Communication Technology (IJEDICT), 15*(1), 209–230. https://files.eric.ed.gov/fulltext/EJ1233891.pdf

Cerezo, R., Sánchez-Santillán, M., Paule-Ruiz, M. P., & Núñez, J. C. (2020). Supporting Self-Regulated Learning Processes in Students with Learning Disabilities in Online Higher Education through an Intelligent Tutoring System. *Sustainability*, *12*(21), 9184. https://doi.org/10.3390/su12219184

Chien, T. C., Yunus, A. S. M., Ali, W. Z. W., & Bakar, A. R. (2008). The Effect of an Intelligent Tutoring System (ITS) on Student Achievement in Algebraic Expression. *International Journal of Instruction, 1*(2), 25–38.

Chou, C. M., Shen, T. C., Shen, T. C., & Shen, C. H. (2022). Influencing Factors on Students' Learning Effectiveness of AI-based Technology Application: Mediation Variable of the Human-computer Interaction Experience. *Education and Information Technologies*, *27*(6), 8723-8750.

Clément, B., Sauzéon, H., Roy, D., & Oudeyer, P.-Y. (2024). *Improved Performances and Motivation in Intelligent Tutoring Systems: Combining Machine Learning and Learner Choice. arXiv preprint arXiv:2402.01669*. Retrieved on 4th May, 2025 from: https://arxiv.org/abs/2402.01669

Conati, C., Barral, O., Putnam, V., & Rieger, L. (2021). Toward Personalized XAI: A Case Study in Intelligent Tutoring Systems. *Artificial Intelligence*, *298*, 103503.

Dascalu, M., Olaru, M., Neagu, L.-M., & Travadel, S. (2022). *Selfit v2: Challenges Encountered in Building a Psychomotor Intelligent Tutoring System.* Retrieved on 4th May, 2025 from: https://www.researchgate.net/publication/361501938_Selfit_v2_-_Challenges_Encountered_in_Building_a_Psychomotor_Intelligent_Tutoring_System

Huq, S. M., Maskeliūnas, R., & Damaševičius, R. (2024). Dialogue agents for artificial intelligence-based conversational systems for cognitively disabled: A systematic review. *Disability and Rehabilitation: Assistive Technology*, *19*(3), 1059-1078.

Imam, S. S., Shuaibu, M., & Haruna, R. (2023). Effects of KOLB's Experiential and GARDNER's Multiple Intelligence Learning Models on Students' Cognitive Achievement in Electrical Installation and Maintenance Work. *WATARI Multidisciplinary Journal of Science & Technology Education*, *7*(2), 45-54.

Muganga, L., & Ssenkusu, P. (2019). Teacher-centered vs. Student-centered: An Examination of Student Teachers' Perceptions about Pedagogical Practices at Uganda's Makerere University. *Cultural and Pedagogical Inquiry*, *11*(2), 16-40.

National Board for Technical Education (2018). National Technical Certificate and Advanced National Technical Certificate Curriculum and Modules Specifications for Basic Electrical/Electronics. National Board for Technical Education Kaduna. Revised Curricular for Technical Colleges and Polytechnics (CD).

Neagu, L.-M. (2022). Intelligent Tutoring Systems for Psychomotor Development in Open Environments (*Doctoral dissertation*, MINES Paris – PSL University & University Politehnica of Bucharest).

Okolie, U. C., Nwajiuba, C. A., Binuomote, M. O., Osuji, C. U., Onajite, G. O., & Igwe, P. A. (2020). How Careers Advice and Guidance can Facilitate Career Development in Technical, Vocational Education, and Training Graduates: The case in Nigeria. *Australian Journal of Career Development*, *29*(2), 97-106.

Oteyola, O. O. (2022). Effects of two selected intelligent tutors on pre-service physics teachers' academic performance in colleges of education in Southwestern Nigeria. *European Journal of Education Studies, 9*(1), 1–14. https://doi.org/10.46827/ejes.v9i1.773

Pandey, A., Bharadwaj, K., Gupta, M., & Tripathi, S. (2024). Effectiveness of Intelligent Tutoring Systems in Improving Learning Outcomes: A Meta-Analytical Study. *Tejas Journal of Technology and Humanities Studies, 3*(2). https://www.tejasjournals.com/Papers/2024/02/TJTHS-0302-003.pdf

Troussas, C., Krouska, A., Alepis, E., & Virvou, M. (2020). Intelligent and Adaptive Tutoring through a Social Network for Higher Education. *New Review of Hypermedia and Multimedia*, *26*(3-4), 138-167.

UNESCO SDG4. (2022). Setting Commitments: National SDG 4 Benchmark to transform Education. Paris: UNESCO Institute for Statistics

Wang, Y., Chen, A., Schweighardt, R., Zhang, T., Wells, S., & Ennis, C. (2019). The Nature of Learning Tasks and Knowledge Acquisition: The Role of Cognitive Engagement in Physical education. *European Physical Education Review*, *25*(2), 293-310.

Modelling the Determinants of Hypermedia Instructional Resource Adoption in Teaching and Learning Digital Electronics in Northern Nigerian Universities

Abdulaziz Bello, Ahmad Aliyu Deba, Paul Shehu Yaduma, and Sa'adatu Abubakar Mohammed, Mustapha Nasiru, Isyaku Muhammad Bello, Abdurrahman Umar Dikko

Abstract

The integration of hypermedia instructional resources offers transformative potential for teaching and learning in technically intensive disciplines such as digital electronics. This research aims to model the determinants influencing the use of hypermedia instructional resources in the teaching and learning of digital electronics courses in universities across Northern Nigeria. As the demand for innovative, technology-driven pedagogy grows, understanding the factors that facilitate or hinder the adoption of hypermedia tools is crucial for enhancing instructional effectiveness and improving student learning outcomes. An explanatory sequential mixed-methods design was adopted for this research. The research commenced with a quantitative phase, involving the administration of structured questionnaires to lecturers and students of digital electronics courses in selected federal, state, and private universities. This phase explored key determinants such as accessibility, perceived usefulness, perceived ease of use, readiness, instructional benefits, and instructional challenges. The utilization of hypermedia resources served as the dependent variable, while variables such as gender, user experience, and university type were examined as moderators. Quantitative data were analyzed using statistical modeling techniques to identify significant predictors. In the subsequent qualitative phase, interviews and focus group discussions were conducted to gain deeper insights into the patterns observed in the quantitative data. This phase explored participants' experiences, challenges, and perceptions regarding the use of hypermedia instructional resources, adding context and depth to the findings. The research is expected to reveal not only the most influential factors driving hypermedia adoption but also the contextual and institutional dynamics shaping their use. The findings will provide valuable recommendations for educational policymakers, curriculum developers, and instructors, supporting the effective integration of hypermedia tools into teaching and learning processes. Ultimately, the research contributes to enhancing digital pedagogy, fostering more engaging and effective learning environments in technology education.

Keywords:
Hypermedia Instructional Resources, Technology Education, Digital Electronics, Mixed-Method, Adoption Determinants

1.0 Introduction

In the 21st century, technology has become an indispensable component of educational innovation, especially in science, technology, engineering, and mathematics (STEM) disciplines (Voogt *et al.*, 2015). Among these, digital electronics stands out as a core subject in technology and engineering education that requires high levels of conceptual understanding, practical application, and dynamic engagement (Gokhale, 2013). Traditional pedagogical approaches often reliant on static textbooks and conventional lectures, are increasingly seen as inadequate for meeting the cognitive and experiential needs of students in this field (Laurillard, 2012; Mayer, 2009). In response, the integration of hypermedia instructional resources has emerged as a promising strategy to enhance the teaching and learning process in technically intensive courses such as digital electronics (Reeves & Reeves, 1997; Akpan & Beard, 2016).

Hypermedia instructional resources, characterized by their use of multimedia elements such as text, audio, video, animations, simulations, and interactive tools, offer nonlinear, user-

driven learning experiences that align with constructivist learning paradigms (Jonassen, 1994; Kay & LeSage, 2009). These resources facilitate greater learner autonomy, engagement, and contextual understanding, which are vital for mastering complex technical concepts (Moreno & Mayer, 2007; Akçayır & Akçayır, 2017). As universities in Northern Nigeria strive to improve the quality of technology education, the adoption of hypermedia resources presents both opportunities and challenges. While some institutions have made strides in leveraging these tools, others continue to face barriers related to infrastructure, digital literacy, institutional readiness, and pedagogical alignment (Adukaite *et al.,* 2017; Oye, Iahad, & Ab. Rahim, 2012).

Despite the recognized potential of hypermedia tools, there is a notable gap in empirical research focusing on the specific factors that influence their adoption within the context of Northern Nigerian universities. Understanding these determinants is critical for developing evidence-based strategies to foster effective integration, particularly in digital electronics education (Tella, 2011; Ifinedo, 2017). It is essential to explore how variables such as accessibility, perceived usefulness, perceived ease of use, readiness, and instructional challenges shape adoption patterns among both lecturers and students. Moreover, demographic and institutional factors such as gender, user experience, and university type may serve as moderating variables that influence the adoption process (Venkatesh & Davis, 2000; Alenezi, 2018).

This research, therefore, seeks to model the determinants of hypermedia instructional resource adoption in the teaching and learning of digital electronics across federal, state, and private universities in Northern Nigeria. Adopting an explanatory sequential mixed-method approach (Creswell & Plano Clark, 2011), the research begins with a quantitative analysis of key predictors of adoption, followed by qualitative inquiry to provide contextual insights. The findings aim to contribute to the growing body of knowledge on educational technology adoption, inform policy and curriculum development, and support instructors in designing more effective, engaging, and learner-centered digital electronics courses. By illuminating the dynamics that drive or hinder the use of hypermedia in higher education, the research offers practical implications for enhancing digital pedagogy in Nigeria's technology education landscape.

2.0 Methodology

This research employed an explanatory sequential mixed-methods design to model the determinants influencing the adoption of hypermedia instructional resources in digital electronics courses across Northern Nigerian universities. The design integrated both quantitative and qualitative phases to enhance the depth and validity of the findings.

2.1 Quantitative Phase

The initial phase involved the administration of a structured questionnaire to a sample of 300 respondents, comprising 50 lecturers and 250 students drawn from selected federal, state, and private universities. A multi-stage sampling technique was adopted to ensure institutional and demographic representation.

The questionnaire, validated by subject-matter experts, covered variables such as accessibility, perceived usefulness, perceived ease of use, instructional readiness, instructional benefits, and instructional challenges, with the adoption of hypermedia tools serving as the dependent variable. Moderator variables included gender, user experience, and university type. Responses were measured on a 5-point Likert scale, and data were analyzed using descriptive statistics, multiple regression, and moderation analysis via SPSS and AMOS.

2.2 Qualitative Phase

To contextualize the quantitative results, the second phase involved semi-structured interviews with 10 lecturers and focus group discussions with 20 students, selected

purposively based on their survey responses. Data were transcribed and subjected to thematic analysis, focusing on participants' experiences, perceptions, and institutional dynamics related to hypermedia usage.

2.3 Ethical Considerations

Ethical clearance was obtained from the relevant institutional review boards. Participants provided informed consent, and anonymity and confidentiality were maintained throughout the research.

3.0 Results / Findings

This section presents the results of both the quantitative and qualitative phases of the research. It includes descriptive statistics, inferential analysis, and qualitative themes that help explain patterns in the data. The findings are organized according to the research variables and hypotheses.

Quantitative Findings

1. Demographic Profile of Respondents

Table 1 presents the demographic characteristics of the respondents.

Variable	Category	Frequency	Percentage (%)
Gender	Male	180	60.0
	Female	120	40.0
University Type	Federal	120	40.0
	State	100	33.3
	Private	80	26.7
User Experience	High (>3 years)	110	36.7
	Medium (1–3 years)	140	46.7
	Low (<1 year)	50	16.6

Table 1 presents the demographic characteristics of the study respondents, highlighting their gender, university type, and user experience with digital tools. The sample comprised 180 males (60.0%) and 120 females (40.0%), indicating a male-dominated respondent group. In terms of institutional affiliation, 40.0% of respondents were from federal universities, 33.3% from state universities, and 26.7% from private universities, ensuring balanced representation across university types. Regarding user experience, 36.7% of respondents reported high experience (more than 3 years), 46.7% had medium experience (1–3 years), and 16.6% had low experience (less than 1 year), suggesting that a majority possessed at least moderate familiarity with hypermedia or digital tools relevant to the study.

2. Descriptive Statistics for Key Variables

Table 2 shows the mean scores and standard deviations of the key variables measured in the **research.**

Variable	Mean ($\bar{x}$)	Std. Dev.	Interpretation
Accessibility	3.87	0.68	High
Perceived Usefulness	4.12	0.61	Very High
Perceived Ease of Use	3.96	0.64	High
Instructional Readiness	3.55	0.72	Moderate
Instructional Benefits	4.08	0.58	Very High
Instructional	3.31	0.80	Moderate

Challenges			
Hypermedia Resource Adoption	3.78	0.66	High

Table 2 presents the descriptive statistics for the key variables measured in the study, including their mean scores, standard deviations, and interpretive ratings. The results show that *Perceived Usefulness* (M = 4.12, SD = 0.61) and *Instructional Benefits* (M = 4.08, SD = 0.58) were rated *Very High*, indicating strong agreement among respondents on the value of hypermedia tools in improving teaching and learning. *Perceived Ease of Use* (M = 3.96, SD = 0.64), *Accessibility* (M = 3.87, SD = 0.68), and *Hypermedia Resource Adoption* (M = 3.78, SD = 0.66) were all interpreted as *High*, suggesting a favorable perception of usability, availability, and actual usage of hypermedia resources. On the other hand, *Instructional Readiness* (M = 3.55, SD = 0.72) and *Instructional Challenges* (M = 3.31, SD = 0.80) received *Moderate* ratings, indicating that while there is some preparedness, notable challenges still hinder full adoption and integration of hypermedia instructional tools in digital electronics education.

3. Regression Analysis

Table 3 displays the results of the multiple regression analysis identifying significant predictors of **hypermedia adoption.**

Predictor Variable	β (Beta)	t-value	Sig. (p-value)	Interpretation
Accessibility	0.23	4.12	0.000	Significant
Perceived Usefulness	0.28	5.45	0.000	Highly Significant
Perceived Ease of Use	0.19	3.21	0.001	Significant
Instructional Readiness	0.11	2.01	0.045	Slightly Significant
Instructional Challenges	-0.17	-2.95	0.003	Significant Negative

Table 3 presents the results of a multiple regression analysis conducted to identify significant predictors of hypermedia adoption in the teaching and learning of digital electronics. The analysis reveals that Perceived Usefulness (β = 0.28, p = 0.000) is the strongest and most highly significant predictor, indicating that the perceived educational value of hypermedia tools plays a central role in their adoption. Accessibility (β = 0.23, p = 0.000) and Perceived Ease of Use (β = 0.19, p = 0.001) are also statistically significant, suggesting that the availability and user-friendliness of these resources positively influence adoption levels. Instructional Readiness (β = 0.11, p = 0.045) shows a slightly significant effect, implying that lecturer preparedness and institutional support moderately affect usage. Conversely, Instructional Challenges (β = -0.17, p = 0.003) exhibit a significant negative influence, demonstrating that barriers such as lack of infrastructure, skills, or policy alignment hinder hypermedia adoption. Overall, these results underscore the multifaceted nature of adoption, shaped by both enablers and obstacles.

4. Moderation Analysis

User experience significantly moderated the relationship between perceived ease of use and adoption ($p = 0.002$). University type showed a marginal moderation effect on accessibility ($p = 0.047$), while gender had no statistically significant effect ($p > 0.05$).

4.1 Qualitative Findings

Theme 1: Positive Attitude Toward Hypermedia Tools

Lecturers and students highlighted the effectiveness of simulations, animations, and interactive tutorials in simplifying abstract digital electronics concepts.

"Using circuit simulation software like Multisim has made it easier to visualize how logic gates work. It's far better than just looking at textbook diagrams." Student, Federal University

Theme 2: Infrastructure and Policy Gaps

Participants cited inconsistent internet access, outdated computers, and insufficient institutional support as major constraints.

"The challenge is not the willingness to use hypermedia, it's the insufficiency of infrastructure and support from university management." Lecturer, State University

Theme 3: Skills and Capacity Gaps

Many lecturers reported limited training on how to integrate hypermedia into their teaching, indicating a need for continuous professional development.

"I'm open to using multimedia tools, but I need training on how to integrate them meaningfully into my teaching." Lecturer,

4.2 Summary of Key Findings

a) Perceived usefulness and ease of use are the most influential positive predictors of hypermedia adoption.
b) Instructional challenges, such as poor infrastructure, significantly hinder adoption.
c) User experience strengthens the adoption process, especially for those with moderate to high exposure.
d) Qualitative data reinforce the importance of institutional investment and faculty training in sustaining hypermedia integration.

5. Discussion

5.1 Analysis of Results in the Context of Existing Research

The results of this research provide valuable insights into the factors influencing the adoption of hypermedia instructional resources in the teaching and learning of digital electronics in Northern Nigerian universities. Consistent with the Technology Acceptance Model (TAM) and its extended frameworks, the research confirmed that perceived usefulness and perceived ease of use significantly affect adoption. These findings align with earlier research by Davis (1989), Teo (2011), and Venkatesh et al. (2003), which assert that individuals are more likely to adopt educational technologies if they perceive them as beneficial and easy to use.

Additionally, the role of accessibility and instructional readiness as positive predictors of hypermedia usage reinforces findings from prior African-based studies (e.g., Oye *et al.,* 2012; Adukaite *et al.,* 2017), which emphasize the importance of digital infrastructure, user support systems, and institutional preparedness in enabling educational technology adoption.

On the contrary, instructional challenges, including limited technical support, internet instability, and insufficiency of training, emerged as significant negative predictors, echoing similar barriers reported in the Nigerian and broader Sub-Saharan African context (Ifinedo, 2017; Olakulehin & Singh, 2013). The research also highlighted that user experience moderated the adoption process, suggesting that prior exposure to digital tools enhances confidence and proficiency in utilizing hypermedia for instruction. This finding corresponds

with studies such as Alenezi (2018), which found that experienced users are more receptive to integrating technology into pedagogy.

Notably, the insufficiency of a statistically significant moderation effect for gender aligns with more recent literature suggesting a closing digital gap between male and female users in higher education, particularly when institutional exposure is equalized (Olatokun, 2008; Tella & Mutula, 2008). However, the research did find modest moderation effects for university type, with federal institutions reporting slightly higher levels of accessibility and usage, possibly due to better funding and infrastructure compared to state and private institutions.

Qualitative findings further deepened the interpretation of statistical results. Students and lecturers widely acknowledged the pedagogical strengths of hypermedia resources, particularly in simplifying abstract content, improving visualization, and fostering learner engagement. However, concerns about inadequate training, insufficient institutional support, and inconsistent ICT policies were consistently raised, indicating that adoption is not solely dependent on individual willingness but also on systemic and organizational readiness.

5.2 Explanation of Implications

The findings of this research carry important implications for stakeholders in the Nigerian higher education sector and beyond:

a) **For Educational Policymakers:** There is a need to formulate clear, actionable policies that mandate and support the integration of hypermedia tools into STEM curricula, particularly in technical courses like digital electronics.

b) **For University Administrators:** The research underscores the importance of investing in digital infrastructure, including stable internet access, modern computer labs, and multimedia content repositories to facilitate hypermedia-based instruction.

c) **For Lecturers and Instructors:** Faculty development initiatives should be intensified to enhance lecturers' capacity to design and deliver instruction using hypermedia tools. Workshops, training programs, and peer mentoring could improve instructional readiness and digital pedagogical competence.

d) **For Curriculum Developers:** Findings suggest the need to revise digital electronics syllabi to incorporate interactive, simulation-based, and multimedia resources, promoting constructivist and learner-centered instructional approaches.

e) **For Technology Developers and EdTech Providers:** Insights from this research can inform the design of hypermedia tools that are contextually appropriate, user-friendly, bandwidth-efficient, and customizable for developing-country contexts.

f) **For Researchers:** The results open avenues for further research on discipline-specific adoption models, comparative regional studies, and longitudinal assessments of hypermedia impact on student learning outcomes and performance.

5.3 Limitations of the Research *(Optional)*

While this research contributes significantly to the literature on educational technology adoption in technical disciplines, it is not without limitations:

a) **Regional Scope:** The research focused on universities in Northern Nigeria; thus, the findings may not be generalizable to other regions or countries with different infrastructural, socio-economic, or cultural contexts.

b) **Cross-sectional Design:** Data were collected at one point in time, limiting the ability to observe long-term trends or changes in adoption behavior.

c) **Self-reported Data:** The use of questionnaires introduces the possibility of social desirability bias or misreporting, particularly on perceived attitudes and usage frequency.

d) **Technology Evolution:** Given the rapid advancement in digital and hypermedia tools, some findings may become outdated if not regularly reassessed in future studies.

Despite these limitations, the mixed-method approach and institutional diversity of the sample enhance the reliability and depth of the findings.

6. Conclusion and Recommendations

6.1 Conclusion

This research investigated the determinants influencing the adoption of hypermedia instructional resources in the teaching and learning of digital electronics in universities across Northern Nigeria. Through an explanatory sequential mixed-method approach, the research examined both quantitative patterns and qualitative experiences of lecturers and students in federal, state, and private institutions.

The results revealed that **perceived usefulness**, **perceived ease of use**, **accessibility**, and **instructional readiness** are key drivers of hypermedia adoption, while **instructional challenges** such as inadequate infrastructure, limited digital skills, and insufficiency of institutional support significantly inhibit usage. Moderation analysis further showed that **user experience** plays a critical role in facilitating adoption, whereas **gender** had no statistically significant effect. Differences across university types were also observed, with federal institutions generally reporting better access and use of hypermedia resources.

Qualitative insights validated these findings, revealing that while students and lecturers recognize the value of hypermedia tools in simplifying complex concepts, several contextual and institutional barriers continue to limit their full integration into teaching practices.

6.2 Summary of Key Findings

a) **Perceived usefulness** and **ease of use** are the strongest positive predictors of hypermedia adoption.

b) **Instructional challenges** negatively influence usage, indicating the need for systemic support and capacity development.

c) **User experience** enhances adoption behavior, highlighting the role of digital literacy and prior exposure.

d) **Institutional context** (university type) affects access and readiness, suggesting disparities in infrastructure and policy implementation.

e) **Qualitative data** emphasized the pedagogical value of hypermedia tools and revealed practical challenges that hinder their effective use.

6.3 Recommendations

Based on the findings and insights derived from this research, the following recommendations are proposed to enhance the adoption and effective utilization of hypermedia instructional resources in digital electronics education across universities in Northern Nigeria:

a) **Strengthen Digital Infrastructure:** Federal, state, and private universities should invest in stable internet connectivity, modern computer laboratories, multimedia projectors, and licensed educational software to support seamless access and utilization of hypermedia tools.
b) **Institutionalize Faculty Training and Support:** Organize regular workshops, seminars, and certification programs to train lecturers on how to effectively integrate hypermedia into their teaching practices, and encourage peer mentoring and knowledge-sharing platforms among instructors to enhance digital teaching competencies.
c) **Embed Hypermedia into the Curriculum:** Curriculum developers should revise digital electronics syllabi to incorporate hypermedia-based instructional methods such as simulations, animations, and interactive modules that support experiential learning.
d) **Promote Student Digital Literacy:** Implement orientation and short-term training for students to build their capacity in navigating and applying hypermedia tools for academic learning and problem-solving.
e) **Develop and Enforce ICT-Integration Policies:** University management should formulate and implement policies that mandate the use of technology-enhanced teaching methods, including guidelines, incentives, and minimum standards for course delivery using hypermedia.
f) **Address Instructional Challenges:** Tackle barriers such as insufficiency of power supply, poor maintenance of digital tools, and limited ICT personnel by allocating adequate resources and technical support at the departmental level.
g) **Encourage Cross-Institutional Collaboration:** Establish partnerships between universities and educational technology providers to co-create customized, low-bandwidth hypermedia content suitable for digital electronics and related fields.
h) **Monitor and Evaluate Implementation:** Set up systems for continuous monitoring and evaluation of hypermedia integration, including tracking usage levels, effectiveness in student learning, and user feedback from both students and faculty.
i) **Provide Incentives for Innovation in Teaching:** Introduce recognition schemes, research grants, or performance-based rewards to motivate lecturers who demonstrate innovative use of hypermedia resources in their teaching.

Reference

Adukaite, A., Van Zyl, I., Er, S., & Cantoni, L. (2017). Teacher perceptions on the use of digital gamified learning in tourism education: The case of South African secondary schools. Computers & Education, 111, 286–303.

Akçayır, M., & Akçayır, G. (2017). The flipped classroom: A review of its advantages and challenges. Computers & Education, 126, 334–345.

Akpan, J. P., & Beard, L. A. (2016). Using Constructivist Teaching Strategies to Enhance Academic Outcomes of Students with Special Needs. Universal Journal of Educational Research, 4(2), 392–398.

Alenezi, A. (2018). Barriers to participation in learning management systems in Saudi Arabian universities. Education and Information Technologies, 23, 2395–2414.

Creswell, J. W., & Plano Clark, V. L. (2011). Designing and conducting mixed methods research (2nd ed.). Thousand Oaks, CA: Sage.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319–340.

Gokhale, A. A. (2013). Collaborative Learning and Critical Thinking. Contemporary Issues in Education Research, 6(2), 91–96.

Ifinedo, P. (2017). Students' perceptions of social media integration in the learning process: A study of a Canadian university. International Journal of Education and Development using ICT, 13(3).

Jonassen, D. H. (1994). Thinking technology: Toward a constructivist design model. Educational Technology, 34(4), 34–37.

Kay, R. H., & LeSage, A. (2009). Examining the benefits and challenges of using audience response systems: A review of the literature. Computers & Education, 53(3), 819–827.

Laurillard, D. (2012). Teaching as a Design Science: Building Pedagogical Patterns for Learning and Technology. Routledge.

Mayer, R. E. (2009). Multimedia Learning (2nd ed.). Cambridge University Press.

Moreno, R., & Mayer, R. E. (2007). Interactive multimodal learning environments. Educational Psychology Review, 19(3), 309–326.

Olatokun, W. M. (2008). Gender and national ICT policy in Africa: Issues and strategies. Information Development, 24(1), 52–61.

Oye, N. D., Iahad, N. A., & Ab.Rahim, N. (2012). The history of the UTAUT model and its impact on ICT acceptance and usage by academicians. Education and Information Technologies, 18(4), 251–270.

Reeves, T. C., & Reeves, P. M. (1997). Effective dimensions of interactive learning on the World Wide Web. In B. H. Khan (Ed.), Web-Based Instruction (pp. 59–66). Englewood Cliffs, NJ: Educational Technology Publications.

Tella, A. (2011). Predicting users' acceptance of e-library from the Technology Acceptance Model (TAM). Journal of Library and Information Science, 3(2), 119–133.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. Management Science, 46(2), 186–204.

Voogt, J., Erstad, O., Dede, C., & Mishra, P. (2015). Challenges to learning and schooling in the digital networked world of the 21st century. Journal of Computer Assisted Learning, 31(5), 391–402.

Exploring AI-Based Innovations in Power Systems and Infrastructure Technology: A Study on Nigerian Economic Development Through Utility Provider and Consumer Insights

[1]JIMBA NYIZO ISRAEL; jimba.nyizo2229@fcesoyo.edu.ng;
[2]OLOSO, SURURAT E. (Ph.D); Oloso.sururat1767@fcesoyo.edu.ng;
[3]LASISI, BASIRU TOYIN (Ph.D); lasisibt@eauedoyo.edu.ng;
4ADEDEJI, SOJI ADEREMI (Ph.D); adedejisa@eauedoyo.edu.ng
5YOHANNA OBADIAH C.; obadiah.yohanna1761@fcesoyo.edu.ng
[1,2,5]Tech. Educ Dept, Sch of Sec Edu (Voc & Tech Prog) Fed Coll of Educ (Special), Oyo
[3,4]Tech Edu Dept, Fac. of Voc. Innov. & Engrg Educ; Emm Alayande Univ. of Educ, Oyo,

Abstract

This study explores the transformative potential of Artificial Intelligence (AI) innovations in Nigeria's power systems, with a focus on their moderating influence on electricity reliability and economic development in sub-urban communities like Iseyin, Oyo State. Despite national reforms and privatization efforts, these regions face persistent power challenges frequent outages, poor maintenance, and minimal smart grid infrastructure which hinder productivity in small- and medium-scale enterprises (SMEs), educational institutions, and households. Leveraging global precedents where AI technologies have enhanced grid efficiency, predictive maintenance, and demand forecasting, this research assesses Nigeria's readiness and gaps in integrating such innovations. Adopting a mixed-methods survey design, data were collected from 200 SME/residential users and 20 utility professionals at the Ibadan Electricity Distribution Company (IBEDC). Findings reveal significant perception gaps between providers and consumers regarding digital service effectiveness, but also shared optimism around AI-enabled tools like prepaid meters and outage alerts. The study highlights the need for participatory planning, transparent communication, and user-aligned deployment of AI technologies to ensure equitable energy access. It further emphasizes that AI can reduce service gaps, optimize infrastructure performance, and boost economic activity if contextualized to Nigeria's socio-economic realities. Ultimately, closing digital trust gaps and aligning AI innovations with local expectations are critical to unlocking inclusive development and modernizing Nigeria's energy systems. The study contributes to a growing body of knowledge advocating for AI-driven, user-centered reforms in African power infrastructure.

Key Words: **Artificial Intelligence (AI), Power Systems, Electricity Reliability, Perception Gaps, Economic Development**

Introduction

Sub-urban communities in Nigeria, such as Iseyin in Oyo State, face chronic electricity challenges characterized by unreliable supply, voltage fluctuations, poor maintenance, and a general lack of access to smart grid infrastructure. According to IseOlorunkanmi (2023), electricity access in these regions remains inconsistent, often worsened by aging infrastructure and insufficient investment. These conditions have adverse effects on small- and medium-scale enterprises (SMEs), educational institutions, and domestic users, undermining socioeconomic progress in the region.

The Nigerian power sector is largely managed by distribution companies (DisCos), such as the Ibadan Electricity Distribution Company (IBEDC) and Benin Electricity Distribution Company (BEDC), which are responsible for power distribution in sub-urban and

rural areas. However, these companies struggle with financial constraints, non-technical losses, vandalism, and consumer apathy (Okedu & Uhunmwangho, 2022). Existing infrastructure in these regions is mostly analog and reactive, with limited integration of modern predictive and preventive technologies.

Globally, Artificial Intelligence (AI) has emerged as a transformative force in power system management. AI technologies support smart grids, enable predictive maintenance of equipment, and enhance energy demand forecasting through machine learning algorithms (Zhao *et al.,* 2021). AI facilitates real-time decision-making by utilities, reduces outages, and optimizes grid performance, thereby improving energy efficiency and customer satisfaction. Countries like China, India, and Germany have recorded measurable improvements in grid reliability and energy management following AI integration (Wang & Wang, 2022).

Moderating influence of AI-based innovations on economic development and reliability of electricity services to affiliate electric power dependent small- and medium-scale enterprises (SMEs), educational institutions, and domestic users has some extended implications. Artificial Intelligence (AI) is transforming global power systems by enhancing electricity production, distribution, and consumption through tools such as smart grids, predictive maintenance, and demand forecasting (Qin *et al.,* 2023). In Nigeria, where energy access remains inconsistent despite abundant natural resources, AI offers a critical opportunity to address electricity reliability challenges and stimulate economic growth. Technologies like intelligent fault detection and data-driven load management can reduce outages, support decentralized systems, and improve service delivery, particularly for small- and medium-scale enterprises (SMEs), educational institutions, and households (Akinyele *et al.,* 2021).

Small- and medium-scale enterprises (SMEs), which contribute over 48% to Nigeria's GDP, are heavily reliant on stable electricity for operations ranging from manufacturing to ICT. Examples like IyinCreative and ColdHubs illustrate how dependable power enables productivity, while outages drive up costs due to reliance on generators (Okonkwo *et al.,* 2022). Similarly, educational institutions need reliable electricity for digital learning, science labs, and administrative functions, with AI-enhanced systems helping to stabilize power supply (Adebayo & Olamide, 2020). At the household level, electricity supports income-generating activities and quality of life, while unreliable power limits economic participation and access to services (Iwayemi, 2020). Furthermore, AI enables utility providers to align electricity supply with demand patterns, reduce technical losses, and improve transparency through smart meters and feedback systems (Uche *et al.,* 2021). Economic development in Nigeria is determined by income, productivity, and access to services depends heavily on consistent electricity (Ebohon *et al.,* 2022). Poor electricity infrastructure hampers industrial and digital progress, while AI presents a solution for real-time monitoring, automated operations, and predictive grid maintenance (NERC, 2024; Nwankwo *et al.,* 2023).

AI-based innovations can moderate the negative effects of unreliable electricity by enhancing system resilience, reducing service gaps, and supporting inclusive development. Realizing this potential, however, requires strategic investments, regulatory support, and an understanding of Nigeria's socio-economic context. Evaluating both provider and consumer perspectives is vital for shaping policies that foster digital energy transitions and sustainable economic advancement.

Literature Review

Literatures reviewed on theoretical framework shows that theories such as Technological Innovation Systems (TIS) framework explores how technology evolves within a system of actors, institutions, and networks. This model is particularly useful in assessing the development, diffusion, and deployment of AI technologies in energy infrastructure (Bergek *et al.,* 2008). TIS considers key functions such as entrepreneurial experimentation,

market formation, knowledge diffusion, and resource mobilization are all essential in understanding the Nigerian power sector's readiness for AI-driven transformation. Similarly, Rogers' (2003) Diffusion of Innovation Theory provides a foundational understanding of how new technologies spread across societies. The theory identifies five adopter categories consisting of innovators, early adopters, early majority, late majority, and laggards, thus highlighting the relevance of socio-economic, cultural, and organizational contexts in technology adoption. This framework is applicable to both utility providers and end-users in Nigeria, where infrastructural, regulatory, and cultural factors influence AI adoption in energy systems. Furthermore, the Socio-Technical Systems Approach views technology as being co-shaped by social, institutional, and technical elements. In power systems, this approach recognizes the interplay between technological tools (like AI and smart grids), organizational routines, policy instruments, and user behaviour (Geels, 2005). It is a suitable lens for analyzing Nigeria's energy landscape, where reforms and innovations must align with community needs and institutional capabilities.

Related empirical studies globally attest to how AI has been instrumental in transforming utility services. In India, AI and machine learning have been integrated into energy forecasting and load management to reduce outages and improve efficiency (Bhardwaj *et al.*, 2021). South Africa has employed AI for grid optimization, addressing technical losses and managing demand side responses in urban and rural settings (Chikuni & Bessarabov, 2020). In the United States, AI applications span from predictive maintenance to grid resilience modelling, supporting proactive infrastructure management and consumer engagement (Kumar & Patel, 2022).

In Nigeria, the reform of the Power Holding Company of Nigeria (PHCN) has led to privatization and the creation of distribution companies like IBEDC and BEDC. Despite these efforts, electricity access remains limited, particularly in sub-urban and rural regions. The Nigerian Electrification Project (NEP) and the Nigerian Energy Support Programme (NESP) aim to address this through off-grid and mini-grid solutions (GIZ & REA, 2022). However, empirical studies focusing on AI integration in these initiatives remain limited. Recent studies indicate challenges in infrastructure, regulatory bottlenecks, and insufficient capacity for AI-based utility innovation (Okafor & Olatunji, 2023).

Smart grids refer to electricity networks that use digital communications technology to monitor and manage electricity flows from all generation sources to meet the varying electricity demands of end-users. They incorporate AI tools to optimize operations, enhance energy efficiency, and integrate renewable energy sources (Fang *et al.*, 2012). Predictive Analysis in Power Systems utilizes AI and machine learning to forecast equipment failures, energy demand, and consumption patterns. It plays a critical role in preventive maintenance and reducing unplanned outages, which is essential in improving the reliability of Nigeria's grid (Zhang *et al.*, 2020).

AI-Driven Infrastructure Management such as application of AI for real-time monitoring, resource allocation, and anomaly detection in energy infrastructure. In Nigeria, AI could support better fault detection, load balancing, and energy theft reduction (Ndukwe *et al.*, 2023). Digital platforms powered by AI, such as chatbots and mobile applications, are increasingly used to engage consumers in energy conservation, bill management, and fault reporting. These tools foster participatory energy use and enable utilities to gather valuable feedback (Aliyu *et al.*, 2022).

Despite the growing body of work on AI in energy systems, several gaps remain:

1. Scarcity of Sub-Urban Focus Studies: Most studies either focus on urban centers or national-level analyses, with limited attention to sub-urban communities that often suffer the most from inadequate power infrastructure.

2. Lack of Cross-Stakeholder Analysis: There is insufficient research that simultaneously considers utility provider perspectives and end-user experiences, particularly in Nigeria.
3. Limited Data on Economic Benefits: Few empirical studies quantify the economic impact of AI-based interventions on local enterprises, productivity, or job creation within Nigeria's power sector.

These gaps underscore the need for multi-dimensional and context-specific research that examines AI's role in advancing energy access and economic development in underserved Nigerian communities. Despite the global momentum, sub-urban Nigerian regions are experiencing technological lag. The absence of real-time data analytics, smart meters, and automated fault detection leaves power utilities reactive and inefficient (Akinyele & Rayudu, 2020). Nevertheless, emerging innovations such as AI-enabled prepaid meters, automated outage notifications, and IoT-based monitoring systems currently present new opportunities for revamping service delivery in these areas. These tools could allow utility providers to better anticipate faults, balance load distribution, and improve billing accuracy.

Successful deployment of AI-based technologies in the power sector hinges on aligning utility provider strategies with consumer expectations. Utility reforms often fail due to poor stakeholder engagement and a top-down approach to technology adoption (NERC, 2023). By integrating consumer and provider perspectives, this study seeks to ensure that innovations are socially acceptable, culturally appropriate, and economically viable.

Statement of the Problem

Despite increased global attention to digital transformation in power systems, Nigerian sub-urban communities continue to experience persistent outages, infrastructure degradation, and under-utilization of operational data. Most power utilities still rely on manual fault detection, estimation-based billing, and delayed maintenance procedures. Furthermore, there exists a disconnect between innovation and implementation, as policies promoting AI and smart grid technologies are often stalled by bureaucratic inefficiencies or lack of funding. Consumers, on the other hand, are rarely consulted in infrastructure planning, resulting in low adoption of new technologies like prepaid metering and energy dashboards.

Despite national reform efforts and privatization of the power sector in Nigeria, sub-urban communities such as Iseyin in Oyo State continue to experience persistent electricity challenges including unreliable supply, voltage fluctuations, inadequate maintenance, and a lack of smart grid infrastructure. These deficiencies severely affect small and medium-scale enterprises (SMEs), educational institutions, and domestic users, thereby constraining economic development and productivity. While Artificial Intelligence (AI) has globally demonstrated transformative capabilities in enhancing power system efficiency through smart grids, predictive maintenance, and demand forecasting, its integration in Nigeria's energy infrastructure, especially in underserved areas remains limited and underexplored.

Current literature reveals a significant gap in empirical studies that assess the moderating influence of AI-based innovations on electricity service reliability and economic outcomes in sub-urban Nigeria. Furthermore, most existing research lacks a dual-perspective analysis that captures both utility provider experiences and consumer insights, which is essential for developing inclusive, sustainable, and context-specific energy solutions. There is also limited evidence on how AI technologies impact local enterprise productivity, educational access, and household welfare in measurable economic terms.

Given the strategic role of electricity in economic growth and the emerging potential of AI-driven technologies, there is an urgent need to evaluate the practical contributions, challenges, and opportunities associated with AI-based innovations in Nigeria's power systems. This study, therefore, seeks to address the critical research gap by exploring how AI

can enhance electricity service delivery and support economic development through the combined perspectives of utility providers and consumers in sub-urban Nigerian communities.

Research Objectives

This study examined the influence of AI-based innovations in enhancing electrical power utility performance and infrastructure development in relation to Nigeria's economic development. Specifically, the study seeks to:

1. Examine the current state of power infrastructure in sub-urban communities.
2. Investigate the awareness and adoption of AI innovations among utility providers.
3. Assess consumer perceptions and responses to AI-enabled power services.
4. Evaluate the influence of AI innovations to economic growth and service reliability.

Research Questions

A. What is the current state of power infrastructure in sub-urban Nigerian communities?
B. What is the level of AI adoption in power utilities in sub-urban Nigeria?
C. What is the perception of consumers on AI-driven services like prepaid metering, outage alerts, and energy management?
D. What is the moderating influence of AI-based innovations on economic development and reliability of electricity services?

Research Hypothesis

The null hypothesis (H_0) below guided the decision for the study:

H_0: AI-based innovations have no significant impact on utility performance and economic development in sub-urban Nigeria.

Methodology

This study adopts a Survey Research Design by using quantitative strategies to provide a comprehensive understanding of the impact of AI-based innovations in power systems on Nigerian economic development. The instrument consists of structured surveys administered to residential and small/medium enterprise (SME) consumers to capture their experiences, satisfaction levels, and perceptions regarding electricity service delivery as well as key utility personnel (e.g., engineers and planners from Ibadan Electricity Distribution Company - IBEDC) to gain expert insights into the integration of AI technologies in utility operations. This design is employed to examine relationships between AI-based innovations and key outcomes such as infrastructure efficiency, service reliability, and economic productivity at a single point in time (Creswell & Plano Clark, 2018; Schoonenboom & Johnson, 2017). This design supports hypothesis testing while allowing for contextual interpretation of technological interventions.

The research is situated in Iseyin, a sub-urban community in Oyo State, Nigeria. Iseyin is strategically selected due to its semi-rural nature, diverse economic activities, and documented challenges with power supply. The town hosts a mix of agricultural processing units, local manufacturing workshops, retail outlets, and residential settlements. Electricity in the area is supplied by IBEDC, which operates under the national grid, with limited use of smart meters and little automation in distribution. Energy access in Iseyin is marked by frequent outages, voltage instability, and limited consumer education on energy use. Economic activities are heavily reliant on power, making the area a suitable context for evaluating AI-enabled innovations such as smart grids, predictive maintenance systems, and AI-driven demand forecasting (Adeniran *et al.*, 2023).

This study focuses on power utilities and residential/commercial consumers in sub-urban Nigerian settings, with emphasis on grid-tied services in locations like Iseyin, Oyo State. While the analysis covers major Distribution Companies (DisCos) such as IBEDC, it does not extend to off-grid or mini-grid systems. Moreover, the scope is limited to AI applications in operational optimization, service delivery, and consumer engagement—

excluding upstream generation and transmission innovations. The target population consists of two distinct groups:

1. Utility Providers: This includes engineers, system planners, and ICT professionals at IBEDC involved in grid management, infrastructure planning, and service delivery.
2. Consumers: Residential users and SME owners operating within Iseyin community.

A stratified random sampling technique is used for consumer respondents to ensure representation across socio-economic status, electricity usage patterns, and business sectors. For the utility providers, purposive sampling is employed to select participants with direct involvement in AI or technological innovation processes (Etikan *et al.*, 2016). The sample size includes: 200 residential and SME; 20 key Utility Providers from IBEDC for Utility Providers.

The instruments used to collect data is a Structured Questionnaire developed to assess consumer access, satisfaction, perceived reliability, and awareness of technological innovations in electricity supply. Likert-scale items are included to measure consumer satisfaction and reliability perceptions. The instrument is designed to explore staff experiences, perceptions, and expert opinions on key thematic areas, including: The current status and readiness for AI adoption within utility operations; Operational and infrastructural challenges in integrating AI tools (e.g., predictive maintenance, smart grid optimization). Perceived benefits and limitations of AI applications in daily workflow and decision-making. Regulatory, policy, and workforce implications of AI-driven innovations in the power sector. These instruments is adapted from similar studies on smart grid adoption and rural electrification (Nwachukwu & Eze, 2022; Akinyele *et al.*, 2020).

To ensure content validity, all instruments were reviewed by three academic experts in energy systems, technology innovation, and quantitative research. The questionnaire and checklist were pilot-tested with 20 respondents outside the study sample in a nearby community (Saki). The internal consistency of the questionnaire is assessed using Cronbach's Alpha (α), reliability of 0.78 (Tavakol & Dennick, 2011). The interview protocol is validated through a member checking process with select IBEDC staff to ensure clarity and relevance of themes.

The data was analyzed using SPSS Version 28. Descriptive statistics (mean scores, standard deviations, frequency distributions) used to summarize respondent characteristics and responses is ANOVA to compare satisfaction levels across Utility Providers Vs Consumers. Ethical standards, including confidentiality, anonymity, and voluntary participation, were strictly maintained, in line with Nigeria's Data Protection Regulation (NDPR, 2023). Data were analyzed using SPSS version 27, with descriptive statistics including mean and standard deviation.

Results and Discussion

The analysis and interpretation of the data obtained from the study provided the basis on which the observed information was interpreted and the discussion of findings was carried out. The test of significance was determined at $\alpha = 0.05$. P-values are derived from independent-samples t-tests (2-tailed). P-values computed here indicate Significance Differences if $p < 0.05$, otherwise, Non-significant Differences ($p \geq 0.05$).

Research Question 1: What is the current state of power infrastructure in sub-urban Nigerian communities?

Table 1: Level of Awareness of Power Infrastructure Status Assessment.

S/N	Expected Awareness	Mean (Provider)	SD	Mean (Consumer)	SD	p-Value	RMK
1	Awareness of availability and reliability of electricity supply in the community	2.46	0.022	3.91	0.292	**0.000**	**S**
2	Ability to identify frequency and duration of power outages in the area	2.41	0.031	3.61	0.527	**0.001**	**S**
3	Knowledge of the primary electricity sources used in the community (e.g., grid, generator, solar)	3.17	0.563	3.46	0.548	**0.226**	N**S**
4	Awareness of the age and condition of power infrastructure (poles, transformers, wiring)	3.12	0.223	3.71	0.457	**0.011**	**S**
5	Familiarity with challenges in accessing stable electricity (technical faults, vandalism, low voltage, etc.)	3.65	0.480	3.78	0.537	**0.572**	N**S**
6	Knowledge of government or private interventions (e.g., mini-grids, upgrades, AI-based monitoring tools)	3.13	0.305	3.48	0.582	**0.109**	N**S**
7	Capacity to assess infrastructure support for new technologies like smart meters or AI-enabled devices	2.27	0.038	3.60	0.563	**0.000**	**S**

From Table 1 (Level of Awareness of Power Infrastructure Status Assessment.), Items 1, 2, 4, 7 show statistically significant differences between utility providers and consumers. These areas reflect distinct awareness levels concerning electricity reliability, outage tracking, infrastructure condition, and readiness for smart/AI tech. Providers often underestimated consumer concerns or overestimated their own knowledge, indicating a gap in perception. While, Items 3, 5, 6 show no statistically Not Significant difference implying shared understanding between both groups regarding energy sources, power challenges, and government/private interventions. These areas might reflect common experiences or shared communication mediums like public campaigns.

Research Question 2: What is the level of AI adoption in power utilities in sub-urban Nigeria?

Table 2: Extent of Awareness of AI Adoption in Power Utilities (Utility Provider vs Consumer Version)

S/N	Expected Awareness	Mean (Provider)	SD	P-Value	Mean (Consumer)	SD	P-Value	RMK
1	Integration of AI tools in operations	2.10	0.005	0.000	3.54	0.633	0.000	**S**
2	AI systems use for load forecasting	2.17	0.002	0.000	3.16	0.677	0.000	**S**
3	Staff training for AI use	2.15	0.077	0.012	3.35	0.510	0.01	**S**

S/N	Expected Awareness	Mean (Provider)	SD	P-Value	Mean (Consumer)	SD	P-Value	RMK
4	AI improving fault detection & maintenance	2.28	0.081	0.001	3.65	0.378	0.001	S
5	Availability of AI infrastructure	2.87	0.028	0.035	3.54	0.358	0.035	S
6	Management support for AI	2.37	0.061	0.040	3.50	0.404	0.040	S
7	Integration of AI with SCADA/smart grids	2.10	0.079	0.000	3.73	0.529	0.000	S

From Table 2 (**Extent of Awareness of AI Adoption in Power Utilities (Utility Provider vs Consumer Version)**, all the 7-Items show statistically significant differences between utility providers and consumers in dimension assessed including: AI tool integration, AI in load forecasting, staff training, fault detection & maintenance, AI infrastructure, availability, management support, integration with Smart Grid.

Research Question 3: What is the perception of consumers on AI-driven services like prepaid metering, outage alerts, and energy management?

Table 3: **General Perception of Service Efficiency as a Result of AI-enabled Innovations**

S/N	Expected Awareness	Mean (Provider)	SD	P-Value	Mean (Consumer	SD	P-Value	RMK
1	Satisfaction with prepaid meters	3.99	0.055	0.001	3.08	0.788	0.001	S
2	Reliability of automated outage alerts	2.05	0.035	0.000	3.03	0.737	0.000	S
3	Belief in smart meter efficiency	3.94	0.130	0.012	3.21	0.091	0.012	S
4	Timeliness of fault/restoration info	2.69	0.015	0.027	3.13	0.019	0.027	S
5	Ease of digital recharge platforms	3.82	0.120	0.213	3.97	0.218	0.213	NS
6	Trust in AI for accurate billing	3.94	0.130	0.168	3.87	0.076	0.168	NS
7	AI-driven solutions improving service delivery	3.79	0.115	0.235	3.73	0.209	0.235	NS

From Table 3 (General Perception of Service Efficiency as a Result of AI-enabled Innovations) the findings from Items 1 - 4 shows that, there is significant differences between utility providers and consumers in areas including: **views** on prepaid meter satisfaction, reliability of AI alerts, effectiveness of smart meters, and communication timeliness; While, Items 5 - 7 show no statistically significant difference implying shared understanding between both groups regarding. ease of digital recharge, trust in AI billing, and service improvement through AI.

Research Question 4: What is the moderating influence of AI-based innovations on economic development and reliability of electricity services?

Table 4: Moderating Influence of AI-based Innovations on Electricity Services

S/N	Expected Awareness	Mean (Provider)	SD	P-Value	Mean (Consumers)	SD	RMK
1	How has the introduction of AI-driven systems (e.g., smart meters, outage prediction) affected electricity service reliability in your area?	1.99	0.88	0.001	3.42	0.684	**S**
2	To what extent do you believe AI-based innovations have contributed to improved economic productivity (e.g., business uptime, reduced generator use)?	2.05	0.90	0.003	3.69	0.465	**S**
3	Has the frequency of power outages reduced since the deployment of AI-enhanced grid systems in your locality?	1.94	0.85	0.002	3.85	0.435	**S**
4	How would you rate the responsiveness of utility providers since the use of AI (e.g., faster fault detection and resolution)?	2.09	0.91	0.004	3.62	0.616	**S**
5	In your opinion, do AI-based energy management tools (e.g., usage alerts, load forecasting) help households or businesses manage costs better?	2.02	0.89	0.003	3.46	0.624	**S**
6	How relevant do you consider AI innovations in addressing challenges of unreliable electricity supply in Nigeria?	3.99	1.20	0.155	3.57	0.624	N**S**
7	Have AI-based power innovations enabled your business or community to operate more efficiently or expand economically?	2.05	1.15	0.035	3.41	0.712	**S**

From Table 4 (Moderating Influence of AI-based Innovations on Electricity Services) the findings from all the Items 1 - 7 shows that, there is significant differences between utility providers and consumers in six out of seven question items, indicating that: AI systems like smart meters and outage prediction tools are perceived by consumers to significantly improve electricity reliability more than by utility providers; Consumers reported higher perceived gains in **economic productivity, reduction in outage frequency,** and **cost management efficiency;** AI's role in **utility responsiveness** and **economic enablement** (efficiency and expansion) was more positively rated by consumers. While, Item 6 showed No Significant

difference implying that AI is highly rated for its efficiency with **more favourable outcomes** in addressing unreliability in electricity supply, suggesting **both groups acknowledge its potential**, though possibly with varying expectations or optimism levels.

Discussion of Findings

The study titled *"Exploring AI-Based Innovations in Power Systems and Infrastructure Technology: A Study on Nigerian Economic Development Through Utility Provider and Consumer Insights"* revealed critical insights into the perception gap and shared understanding between utility providers and consumers concerning Nigeria's electricity infrastructure.

Utility providers often underestimate consumer concerns or overestimate their grasp of electricity service realities. While providers perceive system stability or improvement, consumers in areas like Iseyin, Oyo State, still experience outages, poor voltage, and inconsistent supply (IseOlorunkanmi, 2023; Akinyele & Rayudu, 2020). Additionally, a disconnect exists in AI readiness awareness—providers cite adoption of tools like smart meters and predictive systems, yet consumers remain largely unaware, pointing to a gap in communication and planning (NERC, 2023; Uche *et al.,* 2021). Without addressing this perception divide, AI innovations may struggle to gain traction due to misaligned expectations and limited engagement. These differences emphasize the importance of participatory, user-centered approaches and grassroots data integration in power sector reform. However, alignment between providers and consumers on the role of government and private interventions reveals a shared understanding shaped by public campaigns, media, and collective experiences. Both groups acknowledge challenges such as reliance on gas-powered generation, grid failures, and national efforts like the Nigerian Electrification Project (NEP) and Nigerian Energy Support Programme (NESP) (GIZ & REA, 2022). This common ground can support consensus-building around AI-based off-grid and mini-grid initiatives that depend on cooperation and mutual trust (Akinyele *et al.,* 2021).

Utility providers in Nigeria report higher awareness and internal implementation of AI tools for system monitoring, automation, and forecasting (Zhao *et al.,* 2021; Bhardwaj *et al.,* 2021), yet consumers remain largely unaware, indicating minimal impact on user experience. This perception gap suggests limited communication, transparency, and visible benefits for end-users (IseOlorunkanmi, 2023). While providers highlight staff training, predictive maintenance tools, and management support, these advancements have not translated into improved service reliability, especially in sub-urban areas. Consumers continue to face inefficiencies, reflecting poor integration of AI into broader digital reforms (Akinyele & Rayudu, 2020; Okafor & Olatunji, 2023). The lack of awareness around smart grid integration further underscores the technological lag and underutilization of AI systems in Nigeria's power sector (NERC, 2024; Fang *et al.,* 2012). The results reveal significant perception gaps between utility providers and consumers across four key AI-enhanced service areas. While providers view prepaid meters as improving billing accuracy and satisfaction, consumers report issues such as delayed credits and faulty meters, particularly in sub-urban areas (Ndukwe *et al.,* 2023). Similarly, confidence in AI-powered outage alerts is high among providers but not shared by consumers, who experience delayed or impersonal notifications (Aliyu *et al.,* 2022). Smart meters are also praised by providers, yet many consumers see little benefit due to limited awareness and weak smart grid infrastructure in rural areas (Akinyele & Rayudu, 2020). Lastly, providers rate their AI-enhanced communication as adequate, but consumers highlight delays and poor service interaction (NERC, 2024)

Consumers reported more positive perceptions of AI technologies—such as smart meters and predictive maintenance—than utility providers, citing improvements in billing accuracy, fewer outages, and enhanced service reliability (Akinyele & Rayudu, 2020). They also noted economic benefits like reduced generator use and greater power availability for business operations, aligning with Okonkwo et al. (2022). Conversely, providers may view AI as still in its pilot phase, with limited scalability. Consumers rated AI's role in service responsiveness and digital interfaces higher, reflecting their direct experiences (Aliyu *et al.,* 2022), and showed strong confidence in AI's capacity to support mini-grids and infrastructure expansion (Akinyele *et al.,* 2021). Despite differing optimism levels, both groups acknowledged AI's strategic potential in addressing Nigeria's electricity challenges (Zhao *et al.,* 2021; Qin *et al.,* 2023).

Implications of the Findings

. The study reveals a dual reality in Nigeria's electricity sector: a significant perception gap in technical and digital readiness between utility providers and consumers, and a shared experience regarding energy source challenges (IseOlorunkanmi, 2023). While providers believe in ongoing digital progress, many consumers see little visible service improvement. Bridging this gap requires strategic communication, collaborative planning, and participatory decision-making especially in AI readiness and infrastructure evaluation (Qin *et al.,* 2023). Importantly, shared trust in aspects like digital billing and recharge ease suggests opportunities for expanding AI-based innovations across the power sector.

To ensure meaningful impact, utilities must align AI deployment with user expectations and real-time feedback, particularly in underserved areas. This includes improving the visibility and reliability of AI tools, integrating consumer insights into service planning, and strengthening digital trust systems. Furthermore, sustained investment in smart infrastructure like predictive maintenance and outage management is essential for service reliability and long-term development (Al-Turjman *et al.,* 2022). These findings underscore that consumer participation is critical for AI innovations to drive both economic development and inclusive transformation in Nigeria's power systems.

Recommendation

Based on the findings and implications of the study titled "Exploring AI-Based Innovations in Power Systems and Infrastructure Technology: A Study on Nigerian Economic Development Through Utility Provider and Consumer Insights", the following key recommendations are proposed:

1. Bridge the Perception Gap Through Inclusive Communication by Fostering strategic dialogue between utility providers and consumers to close gaps in AI readiness understanding. Promote transparency on infrastructure capabilities and use public awareness campaigns to demystify AI's role in power systems.
2. Engage Users in Co-Creation and Planning by Including households, SMEs, and schools in participatory planning and co-design of AI-based power solutions. Align innovations with local needs through collaborative platforms that integrate end-user insights into decision-making.
3. Improve Accessibility and Trust in AI Tools by Ensuring AI systems—such as smart meters and billing platforms are user-friendly, reliable, and responsive, especially in underserved areas. Strengthen service quality through usability testing, feedback loops, and targeted infrastructure deployment.
4. Align AI Deployment with Real User Expectations by Moving beyond technical benchmarks by prioritizing service outcomes valued by consumers, such as fairness

and reliability. Leverage existing trust in digital billing and prepaid systems to scale innovations and enhance consumer confidence.

5. Institutionalize Inclusive, Context-Sensitive Strategies by Sustaining AI investment in areas like predictive maintenance and outage management while supporting staff capacity-building. Encourage policies that embed user participation and ensure AI rollouts are culturally relevant, equitable, and development-focused.

References

Adebayo, A. M., & Olamide, M. O. (2020). *Electricity supply and ICT infrastructure development in Nigerian universities: Challenges and prospects*. **International Journal of Educational Development in Africa, 5**(1), 88–97.

Adeniran, A. O., Olowu, T. O., & Adekoya, A. F. (2023). Integrating smart technologies into Nigeria's power infrastructure: Opportunities and implementation challenges. *International Journal of Energy Policy and Management, 9*(2), 45–55. https://doi.org/10.11648/j.epm.20230902.12

Adetutu, M. O., Olayemi, A., & Onifade, M. (2021). *Electricity supply and SMEs productivity in Nigeria: A firm-level analysis*. **Energy Policy, 149**, 112044. https://doi.org/10.1016/j.enpol.2020.112044

Akinyele, D. O., & Rayudu, R. K. (2020). Integrating Renewable Energy and Smart Grid Technology: Challenges and Opportunities in Nigeria. *Renewable and Sustainable Energy Reviews, 132*, 110024. https://doi.org/10.1016/j.rser.2020.110024

Akinyele, D. O., Adepoju, G. A., & Awosope, C. O. (2020). Grid integration and decentralized energy systems for rural electrification in Nigeria. *Energy Reports, 6*, 196–208. https://doi.org/10.1016/j.egyr.2020.11.018

Akinyele, D. O., Awodiji, A. O., & Olatomiwa, L. (2021). *Intelligent energy systems for Nigeria: Application of AI in sustainable power solutions*. *Renewable and Sustainable Energy Reviews*, 135, 110247. https://doi.org/10.1016/j.rser.2020.110247

Aliyu, S., Mustapha, I. A., & Lawal, Y. (2022). AI-enabled platforms for consumer engagement in emerging power markets: A case from Northern Nigeria. *International Journal of Energy Research*, 46(10), 13321–13336. https://doi.org/10.1002/er.7891

Al-Turjman, F., Zahmatkesh, H., & Jabbar, R. (2022). *AI-powered smart grids: Technologies, challenges, and opportunities*. *Journal of Cleaner Production*, 345, 131153. https://doi.org/10.1016/j.jclepro.2022.131153

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., & Rickne, A. (2008). Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. *Research Policy*, 37(3), 407–429. https://doi.org/10.1016/j.respol.2007.12.003

Bhardwaj, R., Singh, A., & Sharma, P. (2021). AI and IoT in Indian smart grid systems: Challenges and future prospects. *Energy Reports*, 7, 5001–5013. https://doi.org/10.1016/j.egyr.2021.08.116

Chikuni, E., & Bessarabov, D. (2020). Artificial intelligence and demand-side management in Southern Africa's smart grids. *IEEE AFRICON Conference Proceedings*, 1–5. https://doi.org/10.1109/AFRICON49881.2020.9367681

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE Publications.

Ebohon, O. J., Ikeme, A. J., & Akinbami, J. F. (2022). *Energy infrastructure and economic development in Sub-Saharan Africa: The Nigerian case*. **African Journal of Science, Technology, Innovation and Development, 14**(3), 697–708. https://doi.org/10.1080/20421338.2021.1951156

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1–4. https://doi.org/10.11648/j.ajtas.20160501.11

Fang, X., Misra, S., Xue, G., & Yang, D. (2012). Smart grid–The new and improved power grid: A survey. *IEEE Communications Surveys & Tutorials*, 14(4), 944–980. https://doi.org/10.1109/SURV.2011.101911.00087

Geels, F. W. (2005). Technological transitions and system innovations: A co-evolutionary and socio-technical analysis. *Edward Elgar Publishing*.

GIZ & Rural Electrification Agency. (2022). *The Nigerian Energy Support Programme: Progress report*. Retrieved from https://www.nesp.org.ng

International Energy Agency (IEA). (2023). *Africa Energy Outlook 2023*. https://www.iea.org/reports/africa-energy-outlook-2023

IseOlorunkanmi, J. (2023). Rural Electrification and Economic Empowerment in Nigeria: A Study of Sub-Urban Dynamics. *Nigerian Journal of Development Studies*, *19*(2), 134–152.

Iwayemi, A. (2020). *Electricity infrastructure and the challenge of sustainable development in Nigeria*. **Energy Economics and Policy Review, 2**(4), 33–48.

Kumar, V., & Patel, D. (2022). AI for resilient power grid infrastructures: A U.S. energy policy perspective. *Energy Policy Journal*, 162, 112793. https://doi.org/10.1016/j.enpol.2022.112793

Ndukwe, E., Ogbonna, J. I., & Obichere, C. (2023). AI-powered monitoring systems for Nigerian energy infrastructure: Opportunities and challenges. *Energy Informatics Journal*, 6(1), 15. https://doi.org/10.1186/s42162-023-00234-8

NERC (2024). *Annual Report on Electricity Distribution and Reliability in Nigeria*. Nigerian Electricity Regulatory Commission.

Nigerian Electricity Regulatory Commission (NERC). (2023). *2023 Annual Report on Distribution Sector Performance*. Abuja: NERC. https://nerc.gov.ng/

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic analysis: Striving to meet the trustworthiness criteria. *International Journal of Qualitative Methods, 16*(1), 1–13. https://doi.org/10.1177/1609406917733847

Nwachukwu, C., & Eze, E. A. (2022). Customer perception of smart meter deployment in Nigerian urban and sub-urban areas. *Energy and Built Environment*. Advance online publication. https://doi.org/10.1016/j.enbenv.2022.11.004

Nwankwo, P. U., Olowu, T. O., & Ezeanya, N. (2023). *Artificial intelligence and digital transformation in African energy systems: Policy, adoption, and implementation pathways*. **IEEE Access, 11**, 50892–50905. https://doi.org/10.1109/ACCESS.2023.3275874

Okafor, C., & Olatunji, T. (2023). Smart energy innovation in Nigeria: Regulatory gaps and technological prospects. *Renewable Energy & Law Review*, 11(2), 84–95.

Okedu, K. E., & Uhunmwangho, R. (2022). Power Sector Reform in Nigeria: A Review of Current Challenges and Prospects. *International Journal of Energy Sector Management, 16*(4), 613–632. https://doi.org/10.1108/IJESM-06-2021-0017

Okonkwo, C. A., Oke, A. O., & Omorogiuwa, E. D. (2022). *Electricity reliability and SME productivity in Nigeria: Evidence and implications*. *Energy Reports*, 8, 12058–12069. https://doi.org/10.1016/j.egyr.2022.09.068

Okonkwo, C. U., Ezeani, E. J., & Abubakar, M. A. (2023). *Energy poverty and entrepreneurial sustainability: Empirical insights from Nigerian SMEs*. **Journal of African Business, 24**(1), 114–132. https://doi.org/10.1080/15228916.2022.2041532

Qin, H., Zhao, Z., & Ding, Y. (2023). *Artificial intelligence applications in smart power systems: A comprehensive review*. *Electric Power Systems Research*, 218, 108991. https://doi.org/10.1016/j.epsr.2022.108991

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). Free Press.

Schoonenboom, J., & Johnson, R. B. (2017). How to construct a mixed methods research design. *KZfSS Kölner Zeitschrift für Soziologie und Sozialpsychologie, 69*, 107–131. https://doi.org/10.1007/s11577-017-0454-1

SMEDAN. (2022). *National Survey of Micro, Small & Medium Enterprises (MSMEs) 2021–2022*. Small and Medium Enterprises Development Agency of Nigeria (SMEDAN). https://smedan.gov.ng/

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education, 2*, 53–55. https://doi.org/10.5116/ijme.4dfb.8dfd

Todaro, M. P., & Smith, S. C. (2020). *Economic Development* (13th ed.). Pearson.

Uche, C. C., Obi, A., & Osuji, C. A. (2021). *Consumer participation and feedback systems in Nigeria's electricity distribution sector: Role of AI and ICTs*. *Energy Policy*, 156, 112432. https://doi.org/10.1016/j.enpol.2021.112432

Wang, Y., & Wang, J. (2022). The Role of Artificial Intelligence in Enhancing Grid Reliability and Cybersecurity. *IEEE Transactions on Smart Grid, 13*(3), 1987–1996. https://doi.org/10.1109/TSG.2022.3145876

Zhang, Y., Zheng, Y., & Wang, Y. (2020). Predictive analytics in electrical grid fault detection: A comparative AI approach. *Journal of Electrical Systems and Information Technology*, 7(1), 1–9. https://doi.org/10.1186/s43067-020-00022-3

Zhao, H., Dong, X., & Li, J. (2021). AI-Driven Smart Grid Systems: Technologies and Applications. *Energy Reports, 7*, 2190–2203. https://doi.org/10.1016/j.egyr.2021.04.083

Zhou, J., Liu, Y., & Wang, Z. (2023). *Data-driven energy systems and the future of digital infrastructure: Role of AI in enabling sustainable development*. *Energy AI*, 11, 100200. https://doi.org/10.1016/j.egyai.2023.100200

INTEGRATING ARTIFICIAL INTELLIGENCE (AI) TOOLS IN TEACHING BASIC ELECTRICITY CONCEPT IN UNIVERSITY OF ILORIN.

Sanni, Tunde Abdulrahman
Department of Educational Technology
Faculty of Education
University of Ilorin, Ilorin
Nigeria.
Sanni.ta@unilorin.edu.ng
(07031107590)

Owodunni, Samuel Ayanda
Department of Industrial and Technology Education School of Science and Technology Education
Federal University of Technology Minna.
s.owodunni@futminna.edu.ng
(07062209015)

Abstract

The rapid evolution of Artificial Intelligence (AI) is transforming industries worldwide, creating an urgent demand for a skilled workforce proficient in emerging technologies. In Kwara State - Nigeria, Technical and Vocational Education and Training (TVET) is critical for equipping students with relevant technical skills; however, integrating AI into these programs remains limited. This study investigated the potential of integrating AI in TVET programs in University of Ilorin Kwara state Nigeria, as a strategic approach to bridge skill gaps and prepare students for the demands of a future workforce. Three research questions guided the study. Descriptive survey design was adopted for the study. The population of the study consisted of 95 academic staff from Faculty of Education. University of Ilorin. Kwara, State and 230 managers from the 230 SMEs in Ilorin making a population of 325. Data for the study were collected through a structured questionnaire on a four-point Likert scale. Internal consistency of the research instrument was tested using Cronbach alpha and a reliability coefficient of 0.88 was obtained. Data collected were analyzed using mean and standard deviation. Findings from the study revealed among others that the availability of AI tools in University of Ilorin Kwara State . Nigeria TVET programs are not sufficient to effectively support students' learning and skill development. The study recommends that to effectively integrate AI into TVET, there should be availability of all resources needed for proper implementation of AI into TVET programs in University of Ilorin Kwara state Nigeria.

Keywords: Artificial Intelligence, TVET, Skills Gap, Workforce Readiness, Education Technology.

Introduction

In the dynamic world of Information Technology, there has been growing need to integrate Artificial Intelligence (AI) and other modern technologies in higher education and TVET in

particular as TVET play a pivotal role in preparing its recipients for the workforce; and equipping them with the necessary skills, knowledge and attitudes to meet the demands of the digital era. AI has been described by Yusuf (2023) as technical and scientific field devoted to the engineered system that generates outputs like forecast, content, and decisions for a given set of human-defined objectives. AI is a useful to people in everyday life as it has the capability to interpret and sort data at scale; solve complex problems and automate varied tasks simultaneously thereby filling operational gaps missed by humans. AI has been applied in various sectors, promoting transformation effects on education, engineering agriculture, law, transportation, medicine, entertainment, among others. (wang, 2024)

Uduafemhe, Ewim and Karfe (2023) noted that TVET as an aspect of education in Nigeria evolved from informal learning system to structured formal education that is geared towards eradicating unemployment, economic stability, and the rapid technological changes impacting the workforce. They went further to state that TVET being driven by innovations in digital technologies, teaching technologies and collaborative learning strategies holds significant promise for improving the employability of the Nigerian workforce thereby enhancing its global competitiveness.

Vocational technical education is a comprehensive term referring to those aspects of the educational process involving in addition to general education, the study of technologies and related sciences and the acquisition of practical skills, attitudes, understanding and knowledge relating to occupations in various sectors of economic and social life, (FRN, 2004). Levesque (2000) submitted that vocational preparation must always be viewed against the backdrop of the needs of the society and of the individual. While meeting the demands of the economy, the abilities of the individuals must be utilized to the fullest meeting the job needs of individuals is a crucial objective of vocational and technical education for sustainable national development.

- Provide trained manpower in applied science, technology and commerce particularly at sub-professional level;
- Provide the technical knowledge and vocational skills necessary for agricultural, industrial, commercial and economic development;
- Provide people who can apply scientific knowledge to the improvement and solution of environmental problems for the use and convenience of man;
- Give an introduction to professional studies in engineering and other technologies;
- Give training and impart the necessary skills leading to the production of craftsmen, technicians and other skilled personnel who will be enterprising and self-reliant; and
- Enable young men and women to have intelligent understanding of the increasing complexity of technology.

AI has significantly impacted diverse sectors including education. TVET institutions are at the forefront of the transformation brought by AI by adopting it to enhance the learning experience and better prepare students for the workforce. Hence, AI provides TVET with opportunities such as tailored educational content as AI can be used to create customized educational content to cater for individual learners' needs (Chiu *et al.,* 2023). It can facilitate interactive and immersive learning experiences using synthetic humans, virtual replicas of machinery, tools, or even historical figures relevant to a particular trade,

providing personalized feedback and learning pathways. Mclaren (2024) identified providing students with real-time feedback, simulating complex business scenarios, and offering a level of interactivity that traditional educational methods cannot match.

To Ndom-Uchendu and Nwokike (2024) personalized learning, improved engagement, enhanced assessment, increased access to education and improved teacher training are some of the impacts of AI in TVET. Alam (2021) noted that leveraging AI technologies has plethora of opportunities to enhance learning experiences, improve student outcomes, create immersive learning environments, and streamline administrative tasks. To Du and Wang (2023) and Westera et al. (2020) AI-driven educational games and simulations offer engaging and interactive ways for students to apply their knowledge and skills in authentic contexts. They further stated that by incorporating elements of blended learning and adaptive learning, educators can create learning environments that are not only fun and engaging but also highly effective in promoting mastery of complex concepts and skills. Olumuyiwa and Ayodele (2023) stated that understanding how to leverage AI in business processes gives students a competitive edge in entrepreneurship, enabling them to innovation and lead in their ventures. They emphasized that AI powered platforms can facilitates collaboration among students by matching them with peers who have complementary skills or interest.

Despite the diverse advantages and opportunities inherent in integrating AI in TVET in Kwara State - Nigeria, Hassan (2022) identified lack of adequate funding of TVET and negative societal perception of vocational education as the major challenges faced in the integration of AI in TVET in Nigeria. Shuaibu (2024) some of the significant challenges facing AI integration in TVET in Nigeria are lack of infrastructure and resources needed to implement AI, and shortage of qualified trainers and AI experts and concerns about the ethical implications of AI. Adefolalu and Okebukola (2020) highlighted that the use of AI raises questions about data privacy, intellectual property and the authenticity of student work as it may be difficult to determine the extent to which a student's work is their own. Adeboye (2023) stressed that there are ethical concerns and the potential for overreliance on AI tools. Adeboye noted that while AI can enhance communication by offering suggestions, grammar corrections and content generation, there is a risk that students may become too dependent on these technologies. This reliance according to Uteh and Iheukwumere (2024) could undermine the development of critical thinking and creative problem solving skills, which are essential to entrepreneurship.

Akeem (2022) identified the need for teachers and students to develop new competences as a challenge in integrating AI into word processing activities in education. Teachers may not be conversant with AI tools or competent enough to integrate them into the curriculum as required. Again, students need to learn how to use these tools which most times are complex. Without good training the potential benefits of AI in word processing such as improving writing skills and automating repetitive tasks, may not be fully realized, limiting its impact on student empowerment, According to Oguniyi (2019), one of the primary issues in integrating AI into word processing activities in education is the lack of access to necessary technology and infrastructure. In many educational institutions, students may not have adequate access to the required software or reliable internet. This can leave some students at a disadvantage and hindering their ability to acquire essential word processing and entrepreneurial skills.

Statement of the Problem

Despite the growing importance of AI in various industries, Nigerian TVET institutions are yet to fully incorporate AI-related curricula and tools into their programs. This has led to a widening gap between the skills taught in schools and the competencies required by employers in the technology-driven economy. If this gap persists, Nigerian youth may face increasing difficulty in securing jobs in the AI-powered industries of the future. The challenge lies in integrating AI technologies and skill-building into TVET to ensure that students are not only prepared but also competitive on a global scale.

Research Questions

- How effectively are AI tools currently being integrated into teaching of basic electricity in University of Ilorin to enhance students' technical and vocational skills?
- What are the key challenges in adopting AI technologies within University of Ilorin to enhance workforce readiness and skill competency?
- To what extent does the use of AI in University of Ilorin TVET programs impact the workforce readiness and employability of graduates in alignment with industry needs?

METHODOLOGY

The descriptive survey research design was adopted for the study. The research design allowed the administration of questionnaire for data generation. The study was conducted in University of Ilorin, Nigeria using academic staff from the five departments in the Faculty of Education University of Ilorin. and 230 Small and Medium- sized Enterprises (SMEs) in Ilorin that are registered with the Kwara State Board of Internal Revenue. The population of the study consisted of 95 academic staff from Faculty of Education. University of Ilorin, Ilorin. and 230 managers from the 230 SMEs in Ilorin making a population of 325. The researchers used the entire population in the study area, this was because the population of the study is manageable and sizable; hence it is a census population.

Data for the study was collected using an 18 item structured questionnaire. The instrument was divided into two sections, A and B. Section A contained items on the respondents' demographic data, while section B contained items addressing the research questions. The respondents were requested to rate the items on a 4-point rating scale of Strongly Disagree - SD, Disagree - D, Agree - A, Strongly Agree – SA. The instrument was validated by three experts and was further subjected to internal consistency testing using Cronbach Alpha which yielded a reliability coefficient of 0.86, 0.90 and 0.88 for clusters B1, B2 and B3 respectively with an overall coefficient value of 0.88. Out of the 325 copies of the questionnaire distributed to the respondents by the researchers with the help of ten research assistants, 300 copies (representing 93%) were duly completed,

retrieved and used for data analysis. Data collected were analyzed using mean and standard deviation. The level of acceptance or rejection of each questionnaire items were determined based on the mean ratings of items interpreted relative to real limits of numbers: Strongly Agree 4 = 3.5-4.00; Agree 3 = 2.5-3.49; Disagree 2 = 1.5-2.49; Strongly Disagree 1 = 1.0-1.49.

PRESENTATION OF RESULTS

- **Research Question 1:** How effectively are AI tools currently being integrated into teaching of basic electricity in University of Ilorin to enhance students' technical and vocational skills?

Table 1: Mean ratings of respondents on the current effectiveness of AI tools integration into teaching of basic electricity in University of Ilorin to enhance students' technical and vocational skills. N = 300

s/n	Item	Mean	Sd	Remark
1	AI tools in TVET programs have significantly improved the technical skills of students.	3.76	0.50	strongly agree
2	The use of AI tools in TVET program provides students with practical, hands-on learning experiences.	3.65	0.79	strongly agree
3	AI-driven tools are effectively integrated into the curriculum to address the specific skill needs of students.	2.16	0.58	Disagree
4	Students in TVET programs benefit from AI tools that offer personalized learning experiences tailored to their skill levels.	3.54	0.68	strongly agree
5	AI tools in TVET programs adequately prepare students for industry-relevant technical competencies.	3.81	0.53	strongly agree
6	The availability of AI tools in Nigerian TVET program is sufficient to effectively support students' learning and skill development.	1.34	0.62	strongly disagree
	Cluster Mean/SD	**3.04**	**0.61**	**Agree**

The result in table 1 revealed that items 1, 2, 4 and 5 were accepted with mean values of 3.76, 3.65, 3.54, and 3.81 respectively; while items 3 and 6 that had mean values of 2.16 and 1.34 respectively were rejected as their mean value were below the cut-off point value of 2.50. However, the cluster mean and standard deviation had a score of 3.04 and 0.61 respectively, thus, the respondents agree that the AI tools currently being integrated into basic electricity TVET programs enhance students' technical and vocational skills.

- **Research Question 2:** What are the key challenges in adopting AI

technologies within University of Ilorin TVET program to enhance workforce readiness and skill competency?

Table 2: Mean ratings of respondents on the key challenges in adopting AI technologies within TVET programs in University of Ilorin to enhance workforce readiness. N = 300

s/n	Items	Mean	SD	Remark
7	Limited Infrastructure and Funding	3.76	0.50	Strongly agree
8	Shortage of Skilled AI Educators and Technicians	3.62	0.67	Strongly agree
9	High Cost of AI Tools and Software	3.73	0.57	Strongly agree
10	Resistance to Technological Change	3.72	0.50	Strongly agree
11	Alignment with Industry Requirements	3.55	0.60	Strongly agree
12	Data Privacy and Security Concerns	3.37	0.72	Agree
	Cluster Mean/SD	**3.62**	**0.59**	**Strongly Agree**

Table 2 analyses indicated that all items were accepted as the key challenges in adopting AI technologies within Nigeria TVET institutions to enhance workforce readiness. The mean values of the 6 items ranged from 3.37-3.76 which are all greater than the cut-off point value of 2.50. The standard deviation values of the six items ranged from 0.50-0.72 which suggests that the responses of the respondents are close to each mean and the other, and they all strongly agree that the key challenges in adopting AI technologies within TVET programs in University of Ilorin enhance workforce readiness and skill competency (mean = 3.62 with a SD = 0.59).

Research Question 3: To what extent does the use of AI in University of Ilorin TVET programs impact the workforce readiness and employability of graduates in alignment with industry needs?

Table 3: Mean ratings of respondents on how the use of AI in TVET programs has impacted on workforce readiness and employability of graduates in alignment with industry needs. N=300.

s/n	Items	Mean	SD	Remark
13	AI-enhanced TVET programs provide students with the technical	3.71	0.52	Strongly agree
14	skills required to meet industry standards and expectations. The use of AI in TVET programs improves students' practical and hands-on skills, making them more employable	3.60	0.62	Strongly agree
15	AI-driven learning in TVET allows graduates to adapt quickly to changing job requirements in the industry.	3.68	0.49	strongly agree
16	Employers recognize AI-based training in TVET graduates as valuable for addressing skill gaps in the workforce.	3.76	0.45	strongly agree
17	AI integration in TVET programs improves students' problem- solving and critical-thinking skills relevant to industry needs.	3.68	0.67	strongly agree
18	Graduates from AI-enhanced TVET programs are more Competitive and ready for workforce demands	2.65	0.65	Agree

	compared to those from traditional TVET programs.			
	Cluster Mean/SD	**3.52**	**0.47**	**Strongly Agree**

The result in table 3 showed that the mean values of the 6 items ranged from 2.65-3.76 which are all greater than the cut-off point of 2.50. This indicates that the 6 identified items in the table are all accepted. The standard deviation values of the items ranged from 0.45-0.65 which suggests that the response of the respondents are close to each mean and the other.

DISCUSSION OF FINDINGS

Research question one sought the current effectiveness of the integration of AI tools into TVET programs in University of Ilorin, Nigeria to enhance students' technical and vocational skills. It was revealed among others that the availability of AI tools in TVET programs in basic electricity in University of Ilorin are not sufficient to effectively support students' learning and skill development; and that AI-driven tools are not effectively integrated into the curriculum to address the specific skill needs of students.

Research question two inquired into the key challenges in adopting AI technologies in TVET programs in basic electricity in University of Ilorin .Nigeria. The findings revealed that some of the key challenges are limited infrastructure, high cost of AI tools and software, resistance to technological change, shortage of skilled AI educators and technicians among others. This result is in line with Shuaibu (2024) who stated that some of the significant challenges facing AI integration in Nigeria are lack of infrastructure and resources needed to implement AI, and shortage of qualified trainers and AI experts.

Research question three investigated the extent to which the use of AI in TVET programs in University of Ilorin has impacted the workforce readiness and employability of graduates in alignment with industry needs. The result revealed that the integration of AI technologies into TVET programs in Kwara State-Nigeria will impact on workforce readiness in alignment with industry needs by providing TVET recipients with the technical skills required to meet industry standards and expectations; practical and hands-on skills; and problem-solving and critical-thinking skills relevant to industry needs. In a related study Maseko (2024) identified problem-solving and critical-thinking, and digital ICT skills as major impacts of integrating AI tools in TVET programs.

CONCLUSION

Based on the findings, the study concluded that integrating AI technologies in TVET programs in basic electricity in University of Ilorin Nigeria will help in bridging skills gaps for the future workforce as TVET play a pivotal role in equipping its recipients with the necessary skills, knowledge and attitudes to meet the demands of the digital era, as well as enabling them to be Self-reliant which in turn will help in eradicating unemployment, and economic instability. Integrating AI technologies in TVET programs will also help in achieving the objectives of TVET according to Federal Republic of Nigeria (FRN, 2014).

Recommendations

- To effectively integrate AI into TVET in University of Ilorin, there should be availability of all resources needed for proper implementation of AI into TVET programs in University f Ilorin Nigeria.
- Government, institutional organizations, private sectors should collaborate to develop training programs that equip trainers with the skills and competencies needed to develop and implement AI based programs in TVET institutions in University of Ilorin Nigeria.
- To address the challenges faced in the integration of AI in TVET in University of Ilorin in Kwara state, Nigeria, a multifaceted approach that will involve government intervention, public awareness campaigns, and increased private sector investment should be adopted.
- To foster partnerships between vocational education institutions and the private sector, TVET institutions in Kwara State should partner with the private sector to identify skills gaps and tailor TVET programs to meet the needs of the job market. This can help ensure that learners are equipped with the skills and competencies needed to succeed in the global economy.

REFERENCES

Adeboye, O. A. (2023). Empowering the next generator: Strategies for business education in Nigeria. *Nigerian journal of business education*.

Adefolalu, F.A., & Okebukola, P. A. (2020). Leveraging technology in entrepreneurship education: A focus on artificial intelligence. *Nigerian journal of educational technology* 8(3), 45-59.

Akeem, U. A. 2022). Artificial intelligence in education: strategies for integration and implementation, Nigerian education research and development council (NERDC) special Issue 12-26.

Alam, A. (2021, November). Possibilities and apprehensions in the landscape of artificial intelligence in education. In *2021 International Conference on Computational Intelligence and Computing Applications*, 1-8.

Chiu, T., Xia, Q., Zhou, X., Chai, C. S., & Cheng, M. (2023). Systematic literature review on opportunities, challenges, and future research recommendations of artificial intelligence in education. *Computers and Education: Artificial Intelligence, 4*, Article 100118. https://doi.org/10.1016/j.caeai.2022.100118.

Du, X., & Wang, X. (2023). Play by design: Developing artificial intelligence literacy through game-based learning. *Journal of Computer Science Research, 5*(4), 1-12.

Federal Republic of Nigeria. (2014). *National policy on education*. NERDC Press.

Hassan, T. A. (2021). *Teaching trade subjects with learner-centered methods: A case for scaffolding and collaborative instructional approaches*. Ruemu-Max Technology Consult.

McLaren, K. W. (2024). *Preparing future leaders: The impact of artificial intelligence in business education*. Forbes Books Author.

Maseko, V. (2024). Overview of skill demand shifts over the decade. https://www.linkedin.com/pulse/emerging-trends-tvet-impact-ai-digitalization-dr-vusi- maseko-phd--gmzqf.

Ndom-Uchendu, & Nwokike. (2024). Influence of artificial intelligence on delivery of business education courses in universities in South-East. *Association of Business Educators of Nigeria* (*ABEN) Conference Proceedings* 11(1), 539-544.

Nie, X. (2020). Research on economic function data and entrepreneurship analysis based on machine learning and computer interaction platform. *Journal of Intelligent and Fuzzy Systems, 39*(4), 563-581.

Nwosu, C. D., Ekoh-Nweke, A. C., & Zion-Ngoka, C. K. (2024). Application of artificial intelligence in entrepreneurship practice in Nigeria. *Association of Business Educators of Nigeria* (*ABEN) Conference Proceedings 11*(1), 967-958.

Oguniyi, M. B. (2019). Innovation approaches to integrating ICT into Nigerian schools for skill acquisition. *Journal of Educational Media and Technology in Nigeria, 23*(2), 79–95.

Olumuyiusa, O. & Ayodele, A. (2023). Empowerment strategies for Nigerian youth. *Journal of Nigerian Educational Research, 15*(2), 45-58.

Shuaibu, N. (2024). Integrating artificial intelligence (AI) in vocational education for sustainable development in Africa. In *Proceedings of the 4th International Conference on Administration and Management (ICAM 2024)*. College of Administration and Management Studies, Hassan Usman Katsina, Katsina State, Nigeria.

Uduafemhe, M. E., Ewim, D. R. E., & Karfe, R. Y. (2023). Adapting to the new normal: Equipping career and technical education graduates with essential digital skills for remote employment. *ATBU Journal of Science, Technology & Education, 11*(4), 51-62.

UNESCO. (2009). *Regional contribution to statistical information systems development for technical and vocational education and training*. http://unesdoc.unesco.org/images/0021/002160/216065e.pdf.

Uteh, C. K., & Iheukwumere, O. C-E. (2024). Empowering students with valuable skills for entrepreneurship integrating artificial intelligence (AI) into word processing activities. *Association of Business Educators of Nigeria* (*ABEN) Conference Proceedings* 11(1), 770-775.

Westera, W., Prada, R., Mascarenhas, S., Santos, P. A., Dias, J., Guimarães, M., Georgiadis, K., Nyamsuren, E., Bahreini, K., Yumak, Z., & Christyowidiasmoro, C. (2020). Artificial intelligence moving serious gaming: Presenting reusable game AI components. *Education and Information Technologies, 25*, 351-380.

World Bank. (2023). Improve technical and vocational education and training (TVET) to meet skills and labor mismatch. *World Bank Reports*. Retrieved from World Bank.

SUB-THEME 3

WEALTH JOB CREATION

ASSESSING THE IMPACT OF INDUSTRY COLLABORATION ON THE EMPLOYABILITY OF TVET GRADUATES IN NIGERIA

BY
PROF. I. OGUNDU
ogundui43@gmail.com.

AND

DR. N. A. NJOKU
njokuanthony76@gmai.'com
1 & 2Department of Industrial Technical Education, Faculty of Vocational and Technical Education, Ignatius Ajuru University of Education, Rumuolumeni, Port Harcourt, Rivers State, Nigeria.

Abstract
This study examined the impact, challenges, and strategies of industry collaboration in Technical and Vocational Education and Training (TVET) in Nigeria, with a focus on enhancing graduate employability and addressing skills mismatch in the labour market. Drawing from recent empirical studies, case analyses, and best practices, the research highlighted how collaborative frameworks between TVET institutions and industry players significantly improve curriculum relevance, practical training opportunities, and job placement rates. Despite these benefits, challenges such as inadequate policy frameworks, poor industry engagement, outdated infrastructure, and societal stigma continue to hinder effective collaboration. The study recommends structured public-private partnerships, involvement of industry in curriculum development, implementation of work-integrated learning, and targeted policy reforms as strategic measures for strengthening industry-TVET collaboration. The findings reinforce the critical role of industry engagement in equipping Nigerian youth with market-relevant skills for sustainable employment and national development.
Keywords: Technical and Vocational Education and Training (TVET), Industry Collaboration, Graduate Employability, Public-Private Partnership (PPP).

I. INTRODUCTION

Technical and Vocational Education and Training (TVET) is pivotal in addressing Nigeria's high unemployment rates and fostering sustainable economic development. However, a significant challenge persists: the gap between the skills imparted through TVET programmes and the actual demands of the labour market. Ntegwung and Njoku (2022) opined that this disconnect often results in a mismatch between the competencies of graduates and the expectations of employers, thereby hindering the employability of TVET graduates.

One of the primary factors contributing to this issue is the limited collaboration between TVET institutions and industries. Effective partnerships between educational institutions and the industrial sector are essential for aligning curricula with current industry standards, providing students with practical experience, and ensuring that training programmes produce graduates with relevant skills. Unfortunately, such collaborations are often insufficient or poorly implemented in Nigeria. Recent studies have highlighted the importance of industry involvement in curriculum development and the integration of work-based learning opportunities. For instance, Otache (2022) emphasized that the wide collaboration gap between Nigerian polytechnics and industries contributes to the unemployability of graduates. Similarly, Ugwoke et al. (2016) noted that Nigerian universities offering TVET courses

implement work-integrated learning to a low extent, citing factors such as poor teacher quality and lack of policy support as major constraints.

Addressing this gap requires a comprehensive approach that includes policy reforms, curriculum enhancements, and the establishment of frameworks that facilitate industry collaboration. By fostering such partnerships, Nigeria can enhance the quality of its TVET programmes, better equip graduates with the skills needed in the workforce, and ultimately contribute to the nation's economic growth and development, (Ogundu 2023)

II. CONCEPTUAL FRAMEWORK

This study adopts a conceptual framework that examines the interplay between Technical and Vocational Education and Training (TVET), industry collaboration, and graduate employability within the Nigerian context. The framework posits that effective partnerships between TVET institutions and industries can bridge the skills gap, enhance curriculum relevance, and ultimately improve the employability of graduates.

1. Technical and Vocational Education and Training (TVET)

TVET refers to education and training programmes that equip individuals with the skills and knowledge required for specific trades or occupations. In Nigeria, TVET is seen as a critical pathway to addressing unemployment and fostering economic development. However, the effectiveness of TVET programmes is often compromised by outdated curricula and inadequate practical training opportunities, (Oluka & Obayi, 2024).

2. Industry Collaboration

Industry collaboration involves partnerships between educational institutions and industries to align training programmes with current market needs. Such collaborations can take various forms, including curriculum development, internships, apprenticeships, and joint research initiatives. In Nigeria, the lack of strong industry linkages has been identified as a significant barrier to enhancing the relevance and quality of TVET programmes. Otache (2022) emphasized that the wide collaboration gap between Nigerian polytechnics and industries contributes to the unemployability of graduates.

3. Graduate Employability

Graduate employability refers to the ability of graduates to secure and sustain employment in their field of study. Employability is influenced by various factors, including the acquisition of relevant skills, work experience, and the alignment of educational outcomes with industry requirements. In Nigeria, many TVET graduates face challenges in securing employment due to the mismatch between their training and the skills demanded by employers. Ugwoke et al. (2016) noted that Nigerian universities offering TVET courses implement work-integrated learning to a low extent, citing factors such as poor teacher quality and lack of policy support as major constraints.

4. Interconnections and Implications

The framework suggests that strengthening industry collaboration can lead to more relevant and practical TVET programmes, thereby enhancing graduate employability. By involving industry experts in curriculum development, providing students with work-based learning opportunities, and fostering partnerships for resource sharing, TVET institutions can better prepare graduates for the labour market. Ejirofor and Ali (2023) highlighted that sharing equipment and tools between TVET institutions and industries and collaboration during curriculum development can address the skills needs of the nation. Furthermore, public-private partnerships (PPPs) have been identified as effective strategies for enhancing TVET-industry linkages. Diogwu et al. (2007) emphasized the importance of PPPs in addressing resource shortages and aligning skills training with market demands.

III. IMPORTANCE OF INDUSTRY COLLABORATION IN TVET

Industry collaboration in TVET is crucial for aligning educational outcomes with labour market needs, thereby enhancing the employability of graduates and contributing to national development.

1. Bridging the Skills Gap

One of the primary benefits of industry collaboration is the alignment of curricula with current industry requirements. Ejirofor and Ali (2023) emphasized that sharing equipment and tools between TVET institutions and industries, along with collaboration during curriculum development, can address the skills needs of the nation.

2. Enhancing Employability through Work-Based Learning

Integrating work-based learning experiences, such as internships and apprenticeships, into TVET programmes equips students with practical skills and real-world exposure. Otache (2022) highlighted that involving industry experts in teaching certain aspects of the curriculum and exposing students to industrial work situations can improve graduates' employability.

3. Facilitating Resource Sharing and Infrastructure Development

Collaborations between TVET institutions and industries often lead to the sharing of resources, including equipment and facilities, which enhances the quality of training programmes. Tibi (2023) noted that partnerships can provide access to modern tools and technologies, thereby improving the learning environment.

4. Promoting Innovation and Research

Industry partnerships foster innovation by facilitating joint research and development initiatives. These collaborations enable TVET institutions to stay abreast of technological advancements and incorporate them into training programmes. The National Board for Technical Education (NBTE) has engaged in partnerships with organizations like Huawei and Cisco to provide faculty with advanced training and resources, ensuring they stay ahead in technology, (NBTE, 2024).

5. Strengthening Policy and Institutional Support

Effective industry collaboration requires supportive policies and institutional frameworks. The Economic Community of West African States (ECOWAS) convened a meeting in November 2024 to validate guidelines for the immersion of TVET graduates into industries, aiming to enhance employability and bridge the gap between educational outcomes and workforce needs, (ECOWAS, 2024).

IV. CHALLENGES OF INDUSTRY COLLABORATION IN TVET IN NIGERIA

Despite the recognized importance of industry partnerships in enhancing the relevance and quality of TVET programmes, several challenges impede their effective implementation in Nigeria.

1. Mismatch between TVET Curriculum and Industry Needs

A significant challenge is the misalignment between the skills taught in TVET institutions and those demanded by industries. Many TVET programmes fail to update their curricula to reflect current industry standards and technological advancements, leading to a skills gap among graduates. This disconnect results in graduates being ill-prepared for the workforce, thereby affecting their employability (Ogundu, 2023).

2. Lack of Industry Involvement in Curriculum Development

Industries are often not consulted during the development and endorsement of national quality standards or course curricula in TVET institutions. This lack of involvement means that training programmes may not address the specific needs and expectations of employers, further exacerbating the skills mismatch (Njoku & Robinson, 2023).

3. Insufficient Infrastructure and Resources

Many TVET institutions in Nigeria are inadequately funded and lack the necessary infrastructure, such as modern workshops and training equipment, to provide quality practical training. This scarcity of resources limits the ability of institutions to deliver training that meets industry standards and expectations (Ogundu, 2023).

4. Bureaucratic and Regulatory Hurdles

The private sector faces numerous regulatory hurdles and bureaucratic processes when attempting to participate in vocational education. These barriers can range from lengthy approval processes to unclear regulations, posing challenges for private sector entities and deterring potential industry partners from engaging with TVET institutions (TVET Journal, 2024).

5. Cultural and Organizational Differences

TVET institutions and industries often operate under different organizational cultures, norms, and values. These differences can lead to misunderstandings and hinder effective collaboration. For instance, industries may prioritize profit and efficiency, while educational institutions focus on pedagogy and student development, leading to potential conflicts in objectives and expectations

6. Political Instability and Policy Inconsistency

Political instability and inconsistent policies in Nigeria can disrupt the continuity and effectiveness of industry collaboration in TVET. Frequent changes in government and policy directions can lead to shifts in priorities, affecting the long-term planning and sustainability of collaborative efforts.(The Guardian Nigeria, 2024)

7. Negative Perception of TVET

There is a societal stigma associated with vocational education in Nigeria, often viewed as a last resort for students who are unable to pursue academic courses. This negative perception discourages students from enrolling in TVET programmes and can affect the willingness of industries to invest in partnerships with these institutions (Ntegwung & Njoku, 2022)

8. Limited Industry Engagement and Awareness

Many industries are not fully aware of the benefits of collaborating with TVET institutions. This lack of awareness leads to limited participation and engagement from the private sector, thereby restricting the opportunities for students to gain practical experience and for institutions to align their training with industry needs

V. STRATEGIES FOR ENHANCING INDUSTRY COLLABORATION IN TVET IN NIGERIA

Effective industry collaboration in TVET is pivotal for aligning educational outcomes with labour market demands, thereby improving graduate employability and contributing to national development. Several strategies have been identified to strengthen these partnerships in Nigeria.

1. Involving Industry Experts in Curriculum Development

One of the fundamental strategies is the active involvement of industry professionals in the development and review of TVET curricula. This ensures that training programs are aligned with current industry standards and technological advancements. Otache (2022) emphasized the need for industry experts to participate in curriculum development to meet today's job requirements in the industry.

2. Establishing Public-Private Partnerships (PPPs)

Public-Private Partnerships are instrumental in bridging the gap between TVET institutions and industries. These collaborations can take various forms, including joint training programs, resource sharing, and infrastructure development. Oyekola and Ogunsuji (2020) highlighted the importance of PPPs in enhancing TVET in Nigeria, noting that such partnerships can lead to improved economic growth and development.

3. Implementing Work-Integrated Learning (WIL) Programmes

Integrating work-based learning experiences, such as internships and apprenticeships, into TVET programmes provides students with practical skills and real-world exposure. Ugwoke et al. (2016) identified strategies for enhancing WIL programmes, including improving synergy between industries and TVET institutions and orienting employers and TVET staff on the benefits of work-integrated learning.

4. Strengthening Industry Advisory Boards

Establishing advisory boards comprising industry representatives can facilitate continuous dialogue between TVET institutions and the private sector. These boards can provide valuable insights into industry trends, skill requirements, and emerging technologies, ensuring that training programs remain relevant and up-to-date.

5. Enhancing Infrastructure and Resource Sharing

Collaborations can also involve sharing resources, such as equipment and facilities, between TVET institutions and industries. Tibi (2023) noted that partnerships can provide access to modern tools and technologies, thereby improving the learning environment.

6. Promoting Policy Reforms and Standardization

Advocating for clear standardization practices, certification, and curricular reforms is essential for aligning TVET programs with global best practices. Stakeholders have emphasized the need for standardization to create opportunities for workers to have varying additions as they progress, peculiar to their employer's goals, (Oluka & Obayi, 2024).

7. Facilitating Networking and Collaboration Platforms

Creating platforms for networking and collaboration, such as career fairs, industry visits, and joint workshops, can foster mutual understanding and trust between TVET institutions and industries. These interactions can lead to the development of joint initiatives and shared goals.

VI. IMPACT OF INDUSTRY COLLABORATION ON EMPLOYABILITY IN NIGERIA

Industry collaboration plays a pivotal role in enhancing the employability of graduates from Technical and Vocational Education and Training (TVET) institutions in Nigeria. By bridging the gap between academic training and industry requirements, such collaborations ensure that graduates possess the practical skills and experience sought by employers.

1. Alignment of Skills with Industry Needs

Collaborations between TVET institutions and industries facilitate the alignment of curricula with current industry standards and technological advancements. This ensures that students acquire relevant skills that meet the evolving demands of the job market. For instance, involving industry experts in curriculum development and review processes helps in tailoring educational programs to the specific needs of employers, thereby enhancing graduates' employability (The Guardian Nigeria, 2024).

2. Practical Experience through Work-Integrated Learning

Work-integrated learning (WIL) programmes, such as internships and industrial attachments, provide students with hands-on experience in real-world work environments. These programmes not only enhance students' technical skills but also improve their soft skills, such as communication, teamwork, and problem-solving, which are highly valued by employers. However, the implementation of WIL in Nigerian universities has been reported to be at a low extent, constrained by factors such as inadequate policy support and lack of industry partnerships, (Jackson, 2020).

3. Increased Employability and Job Placement

Graduates who participate in industry collaborations often have better job placement rates due to their practical experience and industry-relevant skills. Employers tend to favor candidates who have demonstrated the ability to apply theoretical knowledge in practical settings, making industry-collaborated graduates more competitive in the job market, (Disciplines.ng. 2023)

4. Enhanced Career Development Services

Building strong linkages between TVET institutions and industries can facilitate the development of career guidance and counseling services. These services assist students in making informed career choices and preparing for the workforce, further boosting their employability. Effective career development programs, supported by industry partnerships, help graduates transition smoothly into employment, (Eldoret National Polytechnic, 2021)

5. Bridging the Skill Gap

The collaboration between TVET institutions and industries addresses the skill gap by ensuring that training programs are responsive to the changing needs of the labor market. This dynamic approach to education and training equips graduates with the competencies required by employers, thereby enhancing their employability and contributing to national development, (TVET Journal, 2024)

VII. CASE STUDIES AND BEST PRACTICES IN INDUSTRY COLLABORATION FOR TVET IN NIGERIA

1. Polytechnic–Industry Collaboration for Enhanced Employability

A study by Otache (2022) explored the collaboration between Nigerian polytechnics and industries to improve graduates' employability. The research highlighted the involvement of industry experts in curriculum development, exposing students and lecturers to industrial work environments, and establishing a comprehensive collaboration policy framework as key strategies. These practices were found to enhance the relevance of training programs and better align them with industry needs.

2. Work-Integrated Learning (WIL) in Nigerian Universities

Ugwoke et al. (2016) examined the implementation of Work-Integrated Learning (WIL) in Nigerian universities offering TVET courses. The study revealed that while WIL is implemented to a limited extent, factors such as poor teacher quality and lack of policy support hinder its effectiveness. Recommendations included enhancing synergy between industries and TVET institutions, providing adequate orientation for both employers and TVET staff, and redesigning partnership models to attract support from various stakeholders.

3. Collaboration between Technical Colleges and Industries in Edo State

In Edo State, Nigeria, a study focused on the collaboration between technical colleges and industries in the field of motor vehicle mechanic works. The research emphasized the importance of industry involvement in curriculum development, provision of modern teaching facilities, and training of technical teachers to ensure that graduates possess the skills required by the industry. The study highlighted the need for closer ties between educational institutions and industries to bridge the skills gap and enhance employability (Oluka & Obayi, 2024)

4. Eldoret National Polytechnic's Industry Collaboration Model

Although based in Kenya, the Eldoret National Polytechnic's approach to industry collaboration offers valuable insights for Nigeria. The institution partnered with local industries to provide practical training opportunities for students. The collaboration involved joint curriculum development, industry-based assessments, and the use of learning management systems to facilitate communication between the polytechnic and industry partners. This model demonstrates the benefits of strong industry partnerships in enhancing the quality and relevance of TVET programs, (Eldoret National Polytechnic, 2021).

Best Practices for Strengthening Industry Collaboration in TVET

1. Curriculum Co-Development: Engaging industry professionals in the design and review of training curricula ensures that educational programs are aligned with current industry standards and technological advancements.
2. Work-Based Learning Opportunities: Implementing internships, apprenticeships, and industrial attachments allows students to gain hands-on experience and develop practical skills that are directly applicable in the workplace.

3. Continuous Professional Development for Educators: Providing training and development opportunities for TVET instructors helps them stay updated with industry trends and enhances the quality of instruction.
4. Establishing Industry Advisory Boards: Forming advisory boards comprising industry representatives can facilitate ongoing dialogue between educational institutions and industries, ensuring that training programs remain relevant and responsive to labour market needs.
5. Leveraging Technology for Collaboration: Utilizing digital platforms and learning management systems can enhance communication and coordination between TVET institutions and industry partners, especially in remote or underserved areas.

VIII. RECOMMENDATIONS FOR STRENGTHENING INDUSTRY COLLABORATION IN TVET IN NIGERIA

1. Involve Industry in Curriculum Development

TVET institutions should engage industry stakeholders in the design, review, and updating of training curricula to ensure alignment with labor market needs. This will help bridge the existing skills gap and make graduates more employable (Otache, 2022).

2. Institutionalize Work-Integrated Learning (WIL)

Government and educational bodies should mandate and support the implementation of internships, industrial attachments, and apprenticeship programs as integral parts of TVET. These experiences provide students with practical, job-ready skills (Ugwoke *et al.*, 2016).

3. Establish and Strengthen Public-Private Partnerships (PPPs)

TVET institutions should formalize partnerships with private industries through Memoranda of Understanding (MoUs) that outline roles in training delivery, funding, and infrastructure sharing. This fosters resource optimization and mutual accountability.

4. Capacity Building for Educators

Regular training and exposure of TVET instructors to industry practices are essential. Government and institutions should fund professional development programs that allow lecturers to gain current industry knowledge and teaching innovations (Tibi, 2023).

5. Create Industry Advisory Boards

Establishing advisory boards composed of representatives from key industry sectors will ensure constant feedback and ongoing alignment between training programs and industry expectations. These boards can also assist in quality assurance and curriculum relevance.

6. Provide Incentives to Industry Partners

The government should provide tax incentives, recognition awards, and grants to private sector players that actively support TVET programs through internships, mentorship, equipment donations, or joint research initiatives.

7. Strengthen Policy and Regulatory Frameworks

National and state-level education policies should prioritize TVET-industry collaboration. Clear guidelines and legal frameworks will make partnerships more effective, enforceable, and sustainable.

8. Promote Awareness and Value of TVET

A national campaign should be launched to promote the importance and benefits of vocational and technical education. This includes changing public perceptions and encouraging both students and employers to value skilled trades and technical expertise.

IX. CONCLUSION

Industry collaboration is central to the effectiveness and relevance of Technical and Vocational Education and Training (TVET) in Nigeria. As the country grapples with high youth unemployment and a widening skills gap, fostering strong partnerships between TVET institutions and industry stakeholders has become more urgent than ever. The evidence from recent case studies and best practices indicates that such collaboration enhances curriculum

relevance, equips students with practical, industry-aligned skills, and significantly improves their employability.

Despite the clear benefits, challenges such as curriculum mismatch, weak policy implementation, and limited industry involvement persist. However, with deliberate strategies—such as involving industry experts in curriculum design, institutionalizing work-integrated learning, and providing incentives for private sector engagement—TVET in Nigeria can be repositioned to meet the demands of the modern labor market. Ultimately, sustained and structured collaboration between industry and TVET institutions is not only a pathway to improving individual career prospects but also a critical driver of national economic growth and industrial competitiveness.

X. REFERENCES

Adeniyi, J. I. (2023). Collaboration between technical colleges and industries for skills acquisition in motor vehicle mechanic works in Edo state, Nigeria. *International Journal of Research in Education, Humanities and Social Sciences*, 4(2), 34-48.

Diogwu, D. I., Eze, S. C., & Okolie, U. C. (2007). Self-reliance through public-private partnerships in TVET. Policy Brief on Enhancing Technical Education in Nigeria. https://www.nextgenspectrum.com.ng/2024/12/policy-brief-on-enhancing-technical.htm

Disciplines.ng. (2023). Technical schools and industry partnerships: How to strengthen Nigeria's skills development. https://disciplines.ng/technical-schools-industry partnerships

Economic Community of West African States (ECOWAS). (2024). Meeting of Technical Vocational Education and Training (TVET) stakeholders to validate the guidelines on the immersion of TVET graduates in industries. https://www.ecowas.int/meeting-of-technical-vocational-education-and-training-tvet- stakeholders-to-validate-the-guidelines-on-the-immersion-of-tvet-graduates-in-industries-5th-to-8th-november-2024-abuja-nigeria/

Ejirofor, T. E., & Ali, C. (2023). Linking TVET institutions and industries for national development: Challenges and strategies in Nigeria. *Journal of Association of Vocational and Technical Educators of Nigeria*, 20(1), 23-41

Eldoret National Polytechnic. (2021). Collaboration between industry and technical institutions: The Eldoret National Polytechnic experience. *Kenya Journal of Vocational and Technical Education*, 3(1), 41–56. https://tenp.ac.ke/academics/research/research-papers/collaboration-industry-provide-technical-training-case-study

Jackson, D. (2020). Developing career management competencies among undergraduates and the role of work-integrated learning. *Asia-Pacific Journal of Cooperative Education*, 21(1), 1–15. https://doi.org/10.1177/1038416220916814

National Board for Technical Education (NBTE). (2024). Linkages and international collaboration. https://web.nbte.gov.ng/node/54

Njoku, N. A. & Robinson, R. N. (2023). Enhancing family income generation through entrepreneurship in electronics for self-reliance in Port Harcourt Metropolis. *International Journal of Contemporary Academic Research*, 4(3), 1-13.

Ntegwung, G. J. & Njoku, N. A. (2022). Repackaging technical vocational education and training for sustainable national development. *African Journal of Educational Archives*, 8(1), 136- 146.

Ogundu, I. (2023). A Slave does not trade in plantain. The 44th inaugural lecture series of Ignatius Ajuru University of Education, Rumuolumeni, Port Harcourt, Rivers State, Nigeria

Oluka, S. N. & Obayi, A. U. (2024). Dynamics of Technovocational Education in Nigeria. Jeep Global Consult.

Otache, I. (2022). Enhancing graduates' employability through polytechnic–industry collaboration. Industry and Higher Education, 36(5), 604–614. https://doi.org/10.1177/09504222211063140

Oyekola, O. A., & Ogunsuji, O. T. (2020). Public-private partnership: An emerging need for sustainable technical and vocational education training in Nigeria. *International Journal of Research in Education, Humanities and Commerce*, 1(2), 14-29.

The Guardian Nigeria. (2024, March 14). TVET stakeholders demand clear standardisation processes, reforms. Retrieved from https://guardian.ng/news/tvet-stakeholders-demand-clear-standardisation-processes-reforms

Tibi, E. U. (2023). Technical vocational education and training (TVET) and industry partnership for equipping youths for the occupations in Nigeria. *Journal of Association of Vocational and Technical Educators of Nigeria*, 20(2). 24-41. https://www.avten-edu.org.ng/journal/index.php/javten/article/view/107

TVET Journal. (2024). Effective education-industry partnerships in vocational training. https://tvetjournal.com/tvet-institutions/effective-education-industry-partnerships

Ugwoke, E. O., Ezeji, H. A., Edeh, N. I., & Etonyeaku, E. A. C. (2016). Effective implementation of TVET—Industry partnership for employability of graduates through work-integrated learning in Nigerian universities. *Review of European Studies*, 8(3), 307–317. https://doi.org/10.5539/res.v8n3p307

ENHANCING CAREER ENGAGEMENT AND EMPLOYABILITY AMONG TECHNICAL COLLEGE STUDENTS THROUGH DIGITAL SKILLS AND AI FOR ECONOMIC DIVERSIFICATION

Oladiran Stephen OLABIYI, PhD.
Department of Technology and Vocational Education
University of Lagos, Nigeria
&
Sekore, R. BUSARI, PhD.
Department of Technology Education
Faculty of Vocational, Innovation and Engineering Education
Emmanuel Alayande University of Education, Oyo

Abstract

Education offers technical college students the opportunity to gain the skills and knowledge necessary to unlock their full potential in the 21st-century workforce. The digital age has transformed training for technical college graduates, necessitating that teachers acquire digital skills to effectively support students in becoming competent and productive members of a digital society and to develop specific skills for both consuming and producing with technology. Therefore, this paper aims to enhance career engagement and employability among technical college students through digital skills and AI for economic diversification. A descriptive survey research design was utilized, with a sample of 105 technical college administrators and OPS employers. A validated and piloted questionnaire based on a 5-point Likert scale served as the data collection instrument for the study. Data were analyzed using means and standard deviations, facilitated by the Statistical Package for Social Sciences (SPSS). Findings revealed that technical college administrators and OPS employers were satisfied with the digital skills identified through the study as necessary for technical college graduates, indicating that these skills are crucial for effectively preparing graduates for career engagement and employment in the context of economic diversification. Given the nature and complexity of technical college education for career engagement and employability, it is recommended that financial assistance be provided to technical institutions and students to acquire digital tools for practical use in delivering their courses and programmes, and to employ AI-driven platforms that tailor learning experiences to meet individual needs, identify skill gaps, and suggest personalized resources for improvement.

Keywords: Artificial Intelligence; Career Engagement; Economic Diversification; Employment; Digital Skills; Organized Private Sector (OPS); and Technical College.

Introduction

The potential utilisation of digital skills and Artificial Intelligence (AI) in Technical and Vocational Education and Training (TVET) in Nigeria presents significant educational advantages. With the rapid advancement of these technologies, the TVET sector can influence digital tools and AI-supported learning to enhance teaching and learning outcomes. This initiative aligns with global trends, as highlighted by Olabiyi, Ojo, Keshinro, and Okeowo (2020). aimed at developing a skilled workforce in a diversified economy. By adopting digital skills and AI, Nigeria's TVET institutions can improve their effectiveness and offer personalized learning experiences (Olabiy, 2014). This change prepares students for success in the digital age by equipping them with relevant skills and competencies. Furthermore, the use of AI in the curriculum enables students to develop key aptitudes such as data analysis, programming, and other digital competencies essential for today's job market. Additionally, utilizing digital platforms for job searching and networking increases students' visibility to

potential employers, thereby enhancing their career engagement and employability. This comprehensive approach not only prepares students for current job roles but also equips them to thrive in various industries, fostering innovation, emerging jobs, and entrepreneurship.

Technical college is a form of TVET that is a specialized educational institution designed to equip students with practical skills, specialized knowledge, and the attitudes necessary for success in various trades and technical fields. These colleges offer programmes tailored to specific careers, including those in mechanical, construction, and electrical trades (Olabiyi & Chinedu, 2018). The curriculum at technical colleges is carefully structured to combine theoretical learning with hands-on training, enabling students to develop both the technical competencies and real-world experience vital for their chosen or emerging careers. Programmes often include internships, workshops, and laboratory work to ensure that graduates are job-ready and possess the skills employers seek (Olabiyi, 2020) Technical colleges play a crucial role in workforce development, aligning their programmes with the evolving needs of industries by equipping students with skills that are in high demand in the labour market (Becker, 2018). In addition to fostering workforce readiness, technical colleges contribute to economic diversification and support local communities by graduating competent professionals who can meet industry demands. By prioritizing practical skill development, these institutions significantly bolster the economy and ensure that a well-trained workforce is available to satisfy the needs of various sectors (Bailey & Merriam, 2015).

The world of work is experiencing unparalleled transformation, making it increasingly challenging for many workers to keep pace. Those who do not proactively manage their careers may find themselves falling behind. However, there is no need for despair; various strategies and approaches can assist workers in building careers that are both engaging and rewarding. Such strategies inspire individuals to maintain a positive outlook on the future and the vast opportunities it presents. One key concept that can facilitate introspection about work and life is career engagement. Career engagement is the emotional and cognitive connection to one's career, it involves a state of being focused, energized, and deriving enjoyment from various life activities (Pickerell, 2013). In another perspective, career engagement denotes the degree to which individuals are involved and committed to their work. It involves various aspects such as enthusiasm, motivation, and a sense of purpose in one's career. High levels of career engagement can lead to increased job satisfaction, productivity, and overall well-being.

Career engagement is defined as the extent to which individuals are involved in their work roles and are willing to put more effort into their work. (Rothbard, 2001). It is a positive psychological state that reflects one's commitment, satisfaction, and enthusiasm for one's career. Career engagement is influenced by various factors, such as personal characteristics, work environment, career development opportunities, and feedback. (Saks, 2006). In the context of this paper, career is viewed broadly, encompassing not only paid and unpaid work but also learning experiences and diverse life roles throughout one's lifespan. By fostering career engagement, workers can enhance their overall satisfaction and fulfillment, ultimately leading to a more meaningful and productive professional journey. Career engagement refers to the emotional and cognitive connection individuals have with their careers. It embodies a state where one feels focused and energized and finds fulfillment in various life activities.

This concept centers on the dynamic interplay between two key dimensions: challenge and capacity. Challenge pertains to the level of difficulty presented by tasks, encompassing stimulating, fascinating, and invigorating activities. Capacity, on the other hand, refers to the skills, resources, and relationships individuals possess. When the demands of a challenge exceed an individual's capacity, it can lead to feelings of being overwhelmed and disengagement. Conversely, insufficient challenge may result in underutilization of an individual's potential, leading to boredom and a lack of motivation. For individuals to

maintain a state of career engagement, a careful balance between challenge and capacity is essential. When these dimensions are aligned, individuals are more likely to remain engaged, satisfied, and enthusiastic about their work. In contrast, a significant imbalance can lead to complete disengagement, hindering motivation and overall well-being. Becker (2018) posited that Career engagement is important as it enhances one's performance, productivity, and learning outcomes concerning employability. Career engagement in this study refers to a career in digital skills; therefore, a career in digital learning will promote easy job settlement and job security because of productivity and learning outcomes concerning employability.

Employability skills, as described by Lee (2010), act as the driving force behind our increasingly intricate and interconnected workplace. Essential non-cognitive skills such as teamwork, communication, and assertiveness are fundamental attributes sought by employers. Employability refers to the ability to navigate the labour market effectively, enabling individuals to achieve their potential through sustainable employment. This concept is inherently complex and multidimensional, encompassing the skills necessary to find, secure, and transition between jobs in a dynamic and often unpredictable environment. In various educational institutions across the USA, learning outcomes are strategically integrated into comprehensive programs aimed at developing both employability skills and course content knowledge (Partnership for Twenty-First Century Skills, cited in Lee 2010; Olabiyi, 2022). These employability skills encompass a broad spectrum of interpersonal capabilities, including teamwork, negotiation, communication, time management, team leadership, and delegation, all of which are vital for enhancing business operations. Beyond the technical expertise expected of graduates from vocational colleges, employers increasingly value attributes such as proactive problem-solving, effective communication, empathy, motivation, decision-making skills, planning capabilities, and improvisation (Olabiyi, 2022).

To effectively impart these employability skills, educational programmes must focus on engaging, real-world, practical activities that promote discussion, explanation, decision-making, and problem-solving. However, securing and progressing in meaningful employment remains a significant challenge for young people, even during favorable economic conditions, and this is increasingly critical for economic diversification. Therefore, technical colleges must discover innovative strategies to facilitate a smoother transition from school to the workforce. In today's competitive environment, aspirations and competitiveness in the workplace are continually on the rise (Lee, 2010). Employers are increasingly seeking flexible and adaptable young workers (Awofala, Olabiyi, Ogunleye, Udeani, & Fatade, 2017) to navigate the complexities of the emerging global knowledge economy and shifting market dynamics. To address this demand, it is essential to equip technical college graduates with the skills and knowledge necessary to utilize digital tools and AI for economic diversification. Developing these competencies will not only enhance their employment prospects (Kagaari, 2007; Maher & Graves, 2008) but also foster the intellectual, personal, and social resources (Lee, 2010) that empower graduates to thrive in an ever-evolving landscape.

MacDonald, Nink, and Duggan (2010) highlighted that market-driven training necessitates the integration of digital skills and artificial intelligence to accurately assess educational and training needs. This approach aims to meet skill demands and develop strategies to enhance employability skills among technical college graduates in Nigeria. As technology evolves and new skill sets emerge, employees must adapt accordingly. A responsive TVET system should conduct surveys to identify the essential digital competencies required by technical college graduates, recognizing the vital role these competencies play in enhancing career engagement within the industry. Olabiyi, Okeowo, Adedayo, and Ipinlaye (2022) further emphasized that students need access to up-to-date technological information, along with knowledge of environmental issues and entrepreneurial skills, to thrive in their respective fields. The effective utilization of digital skills and AI positions individuals in

Nigeria to succeed in an increasingly digital and competitive landscape. This underscores the importance of embracing technological advancements to meet the diverse demands of a dynamic economy.

The acquisition of relevant knowledge, skills, and abilities significantly increases graduates' chances of success in their chosen careers (Harvey, 2004). For technical and vocational education and training (TVET) institutions, businesses, and governments, the pressing challenge lies in enhancing workforce skills. Elevating employment opportunities and facilitating social mobility through improved employability is crucial for achieving economic diversification and sustaining growth. According to Fugate, Kinicki, and Ashforth (2004), employability involves a type of active adaptability specific to the workplace, allowing individuals to identify and seize career opportunities. Rothwell and Arnold (2007) view employability as the capacity to obtain sustainable employment that aligns with one's qualifications. Similarly, Van der Heijden (2006) describes employability as an ongoing process of fulfilling, acquiring, or creating work through the effective utilization of competencies. Rothwell et al. (2007) proposed a framework of employability that encompasses four key elements: (i). Sustainable Employment, which includes job security and career progression. (ii) Qualifications focusing on formal education and training. (iii) Future-Oriented Perspective emphasizing career planning and development, and (iv). Work Orientation, which pertains to work values and motivation.

Further expanding on this, Van der Heijde (2006) introduced a multidimensional construct of employability that incorporates five dimensions: (a) Occupational Expertise reflecting professional knowledge and skills, (b) Anticipation and Optimization highlighting proactive behaviours, and learning orientation (c) Personal Flexibility denoting adaptability and mobility, (d) Corporate Sense relating to organizational commitment and citizenship behaviour, and (e) Balance which encompasses work-life balance and stress management. Put succinctly, employability can be seen as the driving force that empowers individuals, particularly students in technical colleges, to navigate the labour market and attain sustainable employment.

Policymakers and researchers are increasingly acknowledging the critical importance of economic diversification for the performance of developing economies, making it a key policy priority. Diversification, which involves expanding the variety of economic activities within a country, plays an important role in fostering sustainable growth and enhancing living standards (IMF 2014; Corinne, Giovanni, Monique, Chris, Ke Wang, & Nikola, 2024). This transition is particularly significant for developing economies as it enhances their ability to withstand economic shocks while simultaneously generating new opportunities for innovation, investment, and job creation. Economic diversification is the process of broadening the range of economic activities and industries within a country to minimize reliance on a single sector or commodity. This strategic approach aims to enhance economic stability, bolster resilience against market fluctuations, and create a greater number of job opportunities by promoting a variety of sectors, including manufacturing, services, technology, and agriculture.

Historically, economic diversification has served as a vital strategy for promoting positive economic growth and development. In the contemporary context, particularly within technical colleges, the relevance of economic diversification is heightened by the integration of digital skills and Artificial Intelligence (AI). This integration not only transforms traditional employment landscapes but also creates new opportunities for businesses and job seekers alike. As the demand for diverse employability skills increases, it is crucial to understand how the application of digital skills and AI can impact the development of these skills. This research paper delves into the potential of digital technologies and AI in shaping employability skills among students in technical colleges, exploring how these tools can equip

them for success in a rapidly evolving job market. Through this lens, the study aims to illuminate the pathways for fostering a skilled workforce capable of thriving in a diversified economy.

Economic diversification refers to the transition from reliance on traditional sectors, such as agriculture and extractive industries (like oil and mining), to a wider range of sectors and high-quality services. This diversification is closely tied to structural transformation, the dynamic reallocation of resources from less productive sectors to more productive ones, including knowledge-based industries, such as Information Technology. This sector encompasses software development, cybersecurity, and IT consulting services. Telecommunications: This includes businesses that offer communication services, such as Internet and mobile solutions, leveraging advanced technologies. Additionally, it covers companies that provide specialized engineering services in fields like design, architecture, and construction. Both industries are defined by their reliance on specialized knowledge and expertise, which are crucial for driving growth and fostering innovation. This transformation involves leveraging a country's existing comparative advantages while also developing the capabilities necessary to establish new ones. Such a process is crucial for economic development (Papageorgiou, Spatafora, & Wang 2015; McIntyre et al. 2018). Consequently, diversification acts as a vital pillar for promoting sustainable growth and enhancing living standards, especially in developing economies (IMF 2014). Furthermore, recent global challenges—such as climate change (IMF 2020), technological advancements, and geo-economic fragmentation (IMF 2023a) have underscored the importance of economic diversification in achieving long-term growth (Cherif and Hasanov 2019; Cherif, Hasanov, and Zhu 2016).

Diversification can significantly enhance economic growth, particularly in countries at the early stages of development (Papageorgiou, Spatafora, & Wang 2015; IMF 2014). A substantial body of empirical and theoretical research has explored the often-detrimental relationship between a country's reliance on exhaustible resources and its economic performance, commonly referred to as the Dutch disease and the resource curse. However, the connection between diversification and sustained long-term growth is complex. For instance, the Latin American and Caribbean region has struggled to capitalize on diversification for prolonged economic growth, primarily due to macroeconomic instability (IMF, 2015). When executed successfully, diversification can significantly reduce poverty and inequality by fostering the development of new industries that create jobs and elevate income levels. Engaging in technologically advanced sectors can lead to higher wages and improved employment opportunities (Acemoglu & Autor 2011). Moreover, economic diversification becomes increasingly crucial in the context of climate change. As certain sectors, notably agriculture, face challenges due to changing environmental conditions, diversifying into alternative sectors can bolster economic resilience. Therefore, integrating green technologies and promoting sustainable industries within diversification strategies is essential for future stability and growth.

Statement of the Problem

Technical colleges play a crucial role in preparing students for the workforce by providing vocational and practical training. However, many graduates from these institutions struggle with a lack of essential 21st-century skills, particularly digital competence. This gap can significantly hinder their ability to succeed in their chosen careers or even secure employment. Consequently, many graduates experience feelings of discouragement and depression, and tragically, some may resort to drastic measures, including suicide. According to a publication by Cambridge University Press (2018), mental instability ranks as a leading cause of suicide among young people, driven further by unemployment and social pressures. The deficiency in digital skills and engagement among technical college graduates results in

societal inequality, creating a situation where individuals without formal education but possessing digital competencies are often perceived as more successful. This disparity can lead to increased crime, social vices, and civil unrest, further destabilizing communities. To address these challenges, it is vital to enhance career engagement and employability for technical college students through robust digital skills training and the integration of artificial intelligence for economic diversification. Insights gleaned from this study can inform the technical college administration and the technical education board in Lagos State, guiding them toward policy interventions and the development of practical skills. By improving digital skill training and aligning curriculum design with industry demands, we can ultimately enhance career outcomes for graduates and contribute to greater societal stability.

Research Questions

1. What are the digital competencies essential to effective career engagement and employability skills among technical college graduates?
2. What are the roles digital tools and AI play in enhancing technical college students' employability and career engagement?
3. What are the proposed strategies for improving the use of digital skills and AI in teaching technical college students to enhance their employability and career engagement?

Methods

Research Design

This study employed a descriptive survey research design. Descriptive survey research design is a methodological approach used in social science research to provide a detailed snapshot or portrayal of the current state of a phenomenon without deformation of the concept of the variable. (Neuman, 2014; Creswell & Creswell, 2017), This design was considered suitable for the study since it elicited information from technical colleges administrators and OPS employers in Lagos metropolis.

Population, Sampling, and Sampling Techniques

The population consisted of technical college administrators and organized private sectors (OPS) employers in Lagos metropolis, Southwest Nigeria. The sample consisted of 45 technical college administrators, comprising 5 principals, 10 vice principals, 30 heads of sections, purposively selected from five state-owned technical colleges and 60 OPS employers in Lagos metropolis. Purposive sampling is a non-random method of sampling whereby the researcher selects information-rich cases for study (Ogunleye, 2000). Altogether, the sample consisted of technical college administrators and OPS employers with varied years of administrative/teaching experience. In contrast, OPS employers with staff strength minimum of 20 and accept students for industrial work experience scheme were considered.

Instrumentation

The instrument for data collection was a structured questionnaire. The instrument had four sections, A to D. Section A sought information on personal data of the respondents such as status, years, and working experience. Section B to D sought information on the three research questions. The questionnaire was subjected to face and content validation by three experts. The internal consistency of the instruments was determined using Cronbach Alpha, with an alpha value of $\alpha = .88$. The instrument was administered to the respondents through research assistants and personal contact. Out of 105 questionnaires administered, 101 were duly filled and returned to the researcher. These represented 96 % questionnaire retrieval rate. Data generated from the questionnaire were analysed using descriptive statistics, particularly

mean and standard deviation, through the Statistical Package for Social Sciences (SPSS), version 20.

RESULTS AND DISCUSSION

Research Question One: What are the digital competencies essential to effective career engagement and employability skills among technical college graduates? To determine the responses of technical college administrators and OPS employers' regarding the digital competencies necessary to effective career engagement and employability skills among technical college graduates for economic diversification, mean and SD were used to summarize the responses of respondents to determine their level of agreement or disagreement with each of the items presented in the questionnaire. The mean and SD are presented in Table 1 below.

Table 1: Digital competencies essential to effective career engagement and employability skills among technical college graduates (N=101)

No	Items	Mean	SD
	EMPLOYABILITY		
Compt. 1	Competent in operating industry-specific software like AutoCAD to design and install fittings and patterns on constructed projects.	3.71	.48
Compt. 2	Competence in keeping pace with AI tools, IoT, and machine learning applications, and prepared to learn as technologies evolve.	3.80	.40
Compt. 3	Exhibit competency in digital skills, including the use of educational software, online tools, and multimedia resources for teaching	4.50	.51
Compt. 4	Demonstrate the capacity and knowledge of technical and critical skills necessary for integrating digital technology.	3.66	.48
Compt. 5	Engage students with hands-on activities while staying current with rapidly evolving technology	3.68	.86
Compt. 6	Competency in utilizing coding platforms, data visualization software, collaborative tools, and simulation software	3.86	.84
Compt. 7	Competency in effectively utilizing digital technology to enhance the management of learning needs and learner experiences.	3.76	.85
Compt. 8	Ability to use digital technology to address the demands of the contemporary labour market within TVET areas	4.34	.73
Compt. 9	Ability to identify and explain digital competencies that will influence future trends in TVET and need to be incorporated into the curriculum.	3.76	.61
	CAREER ENGAGEMENT		
Compt. 10	Competency in developing strategies for incorporating digital competencies to enhance the training of TVET educators.	3.69	.65
Compt. 11	Ability to analyze industrial support and initiatives that assist TVET educators in developing competencies for integrating digital tools.	3.66	.84
Compt. 12	Competent in using digital technologies to analyze emerging industrial processes and activities that impact the TVET curriculum	3.79	.58
Compt. 13	Ability to discuss practical ways of using digital technology to improve students' competencies within TVET programmes	3.82	.48

Compt. 14	Competent in the implementation of digital technologies to enhance pedagogical methodologies and practices within TVET education.	4.08	.63
Compt. 15	Proficiency in effective email usage and document creation using word processors, among other digital skills in classroom/laboratories	4.27	.72
Compt. 16	Ability to use the specific components of digital citizenship, online safety, and best practices for managing students' data privacy.	4.34	.73
	Total	**4.15**	**.47**

Responses of technical college administrators and organized private sectors (OPS) employers regarding career engagement and employability among technical college students through digital skills and AI for economic diversification. Table 1 presents the mean and standard deviation of technical college administrators and employers in the organized private sector regarding the digital competencies essential to effective career engagement and employability skills among technical college graduates. The overall mean score of 4.15 shows that technical college administrators and employers in OPS indicated that digital competencies are essential for effective career engagement and employability skills of technical college graduates. Among which include: competency in operating industrial specific software like AutoCAD to design and install fittings and patterns on constructed projects; keeping pace with AI tools, IoT, and machine learning applications, and prepared to learn as technologies evolve; the use of educational software, online tools, and multimedia resources for teaching; using digital technology to address the demands of the contemporary labour market within TVET areas; in the implementation of digital technologies to enhance pedagogical methodologies and practices within TVET education; effective email usage and document creation using word processors, among other digital skills in classroom/laboratories; and competence to use the specific components of digital citizenship, online safety, and best practices for managing students' data privacy. The following items on the scale had mean values ranging from 3.55 to 4.50, which is above the cut-off point of 3.50 on the %point Likert scale.

Research Question Two: What roles do digital tools and AI play in enhancing technical college students' employability and career engagement? To determine the responses of technical college administrators and OPS employers' regarding the role's digital tools and AI play in enhancing technical college students' employability and career engagement for economic diversification, mean and SD were used to summarize the responses of technical college administrators and OPS employers and to determine their level of agreement or disagreement with each of the items presented in the questionnaire. The mean and SD are presented in Table 2 below.

Table 2: Roles digital tools and AI play in enhancing technical college students' employability and career engagement (N=101)

No	Items	Mean	SD
	EMPLOYABILITY		
Role1	Digital tools and AI platforms offer students access to online courses, simulations, and virtual labs to cultivate valuable technical and soft skills.	4.08	.63
Role 2	Digital platforms enable students to connect with industry experts and peers, enhancing their professional networks	3.71	.61
Role 3	AI systems can tailor educational content to individual needs, helping students improve in areas of weakness and build on their strengths.	4.34	.73
Role 4	Knowledge of AI and digital tools helps students quickly adapt to technological changes in the future workplace.	4.40	.74
Role 5	AI systems can tailor educational content to individual needs, helping students improve in areas of weakness and build on their strengths.	3.82	.48

Role 6	Digital tools help students showcase their work, like designs or technical solutions, making them more appealing to employers.	4.27	.72
Role 7	AI tools help students create enhanced resumes and prepare for interviews through mock sessions and feedback.	4.15	.63
Role 8	AI tools simulate real-world situations, providing practical knowledge in robotics, programming, and data analysis for technical roles.	3.71	.61
	CAREER ENGAGEMENT		
Role 9	Digital tools provide actual information on labour market activities, skills, and emerging opportunities, helping students adapt to changes in their fields.	3.82	.48
Role 10	AI-powered platforms help students use different career paths by examining their interests, strengths, and goals for industries and roles that align with their skills.	4.27	.72
Role 11	Platforms like industry-specific networks allow students to connect with professionals and potential employers, developing valuable career opportunities.	3.58	.52
Role 12	Digital tools could help students focus on developing critical soft skills like communication, teamwork, and adaptability, which are essential for career success.	4.70	.51
Role 13	AI-based systems could connect students with internships and entry-level jobs that suit their profiles, increasing their chances of securing meaningful positions.	3.71	.61
Role 14	Students can demonstrate their skills through digital certifications, badges, and portfolios, demonstrating their abilities to potential employers.	4.34	.73
Role 15	Gamified learning platforms and AI-driven simulations help make acquiring new skills more engaging, keeping students motivated and invested in their career development.	3.58	.52
	Total	**4.35**	**.47**

Table 2 shows the mean responses of the technical college administrators and organized private sectors (OPS) employers regarding the roles digital tools and AI play in enhancing technical college students' employability and career engagement. The role of digital tools and AI identified through the study includes: offering students access to online courses, simulations, and virtual labs to cultivate valuable technical and soft skills; enable students to connect with industry experts and peers, enhancing their professional networks; AI systems can tailor educational content to individual needs, helping students improve in areas of weakness and build on their strengths; tools helps students quickly adapt to technological changes in the future workplace; , help students showcase their work, like designs or technical solutions, making them more appealing to employers; help students use different career paths by examining their interests, strengths, and goals for industries and roles that align with their skills; help students focus on developing critical soft skills like communication, teamwork, and adaptability, which are essential for career success, and helps students demonstrate their digital certifications, badges, and portfolios, demonstrating their abilities to potential employers. With means values ranging from 3.58 to 4.70 above the cut-off point of 3.50, it was evident that the technical college administrators and OPS employers considered digital tools pertinent to the training of technical college graduates for economic diversification.

Research Question Three: What are the proposed strategies for improving the use of digital skills and AI in teaching technical college students to enhance their employability and career engagement? To determine the responses of technical college administrators and OPS employers' regarding tthe proposed strategies for improving the use of digital skills and AI in teaching technical college students to enhance their employability and career engagement for economic diversification, mean and SD were used to summarize the responses of respondents to determine their level of agreement or disagreement with each of the items presented in the questionnaire. The mean and SD are presented in Table 3 below.

Table 3: Strategies for improving the use of digital skills and AI in teaching technical college students to enhance their employability and career engagement (N=101)

No	Items	Mean	SD
Stra. 1	Integrate digital skills and AI-related themes into the TVET curriculum, ensuring students gain practical experience with appropriate technology.	4.27	.72
Stra. 2	Include industry-specific software and AI applications to align with job market demands in TVET curriculum.	4.15	.63
Stra. 3	Offer professional development programmes for TVET educators to enhance their proficiency in digital tools and AI.	3.71	.61
Stra. 4	Empower TVET teachers to adopt innovative teaching methods, such as flipped classrooms and AI-driven personalized learning.	4.15	.70
Stra. 5	Equip technical colleges with up-to-date hardware, software, and internet connectivity to ensure students have access for practicing and facilitating digital learning.	4.08	.63
Stra. 6	Encourage collaboration with establishments to provide students with real-world projects, internships, and mentorship opportunities.	3.71	.61
Stra. 7	Organize workshops and seminars on emerging technologies to increase students' awareness concerning the importance of digital skills and AI in career development.	4.34	.73
Stra. 8	Use AI tools for real-time assessment and feedback, helping students track their progress and improve continuously.	4.40	.74
Stra. 9	Use digital tools to teach communication, teamwork, and problem-solving skills, which are critical for employability and career engagement.	3.82	.48
Stra. 10	Employ AI-driven platforms to tailor learning experiences to meet individual needs, identify skill gaps, and recommend personalised resources for improvement.	4.27	.72
Stra. 11	Simulate workplace situations using AI and digital skills to prepare students for digital environments.	4.40	.74
Stra. 12	Allocate projects that require students to use AI and digital tools to solve practical problems, encouraging critical thinking and innovation.	3.82	.48
Stra. 13	Encourage a growth mindset in students by emphasizing the importance of lifelong learning and adaptability in career engagement.	4.27	.72
Stra. 14	Make use of AI-driven analytics to monitor students' career progress, identifying areas of strength and improvement needs	4.15	.63
Stra. 15	Prepare students to use digital tools effectively for networking, such as improving LinkedIn profiles and engaging in professional groups.	3.71	.61
	Total	**4.05**	**.64**

Table 3 presents the mean and standard deviation of technical college administrators and employers in the organized private sector vis-à-vis the proposed strategies for improving the use of digital skills and AI in teaching technical college students to enhance their employability and career engagement. The overall mean score of 4.05 shows that the proposing strategies for improving the use of digital skills and AI in teaching technical college students to enhance their employability and career engagement identified from the study among others includes: integrating digital skills and AI-related themes into TVET curriculum, ensuring students gain practical experience with appropriate technology; include

industry-specific software and AI applications to align with job market demands in TVET curriculum; empower TVET teachers to adopt innovative teaching methods, such as flipped classrooms and AI-driven personalized learning; organize workshops and seminars on emerging technologies to increase student's awareness concerning the importance of digital skills and AI in career development; employing AI-driven platforms to tailor learning experiences to meet individual needs, identify skill gaps, and recommend personalised resources for improvement; encouraging a growth mindset in students by emphasizing the importance of lifelong learning and adaptability in career engagement; making use of AI-driven analytics to monitor students' career progress, identifying areas of strength and improvement needs, and preparing students to use digital tools effectively for networking, such as improving LinkedIn profiles and engaging in professional groups. With means values ranging from 3.71 and 4.40 above the cut-off point of 3.50, it was apparent that the respondents considered the proposed strategies for improving the use of digital skills and AI in teaching technical college students to enhance their employability and career engagement for economic diversification.

Determining technical college administrators' and employers' perceptions regarding the essential digital competencies, roles of digital tools, and strategies for improving the use of digital skills and AI in teaching technical college students to enhance employability and career engagement for economic diversification was the main goal of the study. Findings from the results presented in Table 1 revealed that Nigerian employers in organised private sectors (OPS) and technical college administrators are satisfied with the identified digital competencies essential to effective career engagement and employability skills of technical college graduates in Nigeria. They emphasised that technical college programmes need to develop these digital skills to prepare competent skilled and semi-skilled workers on the use of digital tools and the development of its associated skills to satisfy the needs of the Nigerian workforce to enhance enhance employability and career engagement for economic diversification. This finding is consistent with the view of Olabiyi (2020), who explained that to succeed in today's competitive job market, technical college graduates need a set of digital competencies that are aligned with effective employability skills. Understanding these competencies ensures that graduates are prepared to meet employer expectations, adapt to technological advancements, and contribute effectively to their organizations. The finding agrees with the perception of Garry (2020) and Olabiyi and Chinedu (2018), who believe in the need to expand technical college students' understanding of the sort of competencies required to function productively, safely, and ethically in diverse and increasingly digitally-mediated environments. The authors highlight the importance of digital competencies concerning technical college graduates' future employment, empowering technical college graduates to help them build their capacity to leverage advantage from digital resources and information in a safe, secure, and sustainable way. Effective employability and career engagement among technical college graduates require knowledge of several digital competencies. These are crucial for circumnavigating the modern workforce, maintaining employability, and thriving in dynamic professional environments (Borthwick & Hansen, 2017). These competencies not only enhance employability but also empower graduates to actively engage with career opportunities, contribute effectively to their workplaces, and adapt to the ever-evolving digital landscape.

Regarding technical college administrators and employers' perceptions of roles, digital tools and AI play in enhancing technical college students' employability and career engagement for economic diversification. Administrators and OPS employers believe that digital tools are essential in transforming technical colleges in producing a competent graduate for employability and career engagement toward economic diversification. They note that emerging digital tools change the entire focus of manpower needs in the world from

skill-based to a technology-capable workforce and increase motivation and engagement by facilitating the acquisition of workforce skills. These findings are congruent with the opinion of Olabiyi (2014) and Ottestad, Kelentrić, and Guðmundsdóttir (2014), who emphasised that if technology tools are to make an impact in the world of work, then there is also a need for knowledgeable workers skilled in digital tools. Digital skills afford access to resources and critical analysis of information. Students could use digital tools to explore connections and develop communication, collaboration, and critical thinking. Developing digital skills in learners makes them feel supported to become competent learners in a digital age. Digital literacy allows teachers to assist students in communicating, collaborating, and understanding the complexities of what they are using (Abiwo, Olabiyi, Olafare, & Odumuyiwa, 2023; Awofala, Olabiyi, Awofala, Ojo, Okunuga, & Lawani, 2020). Digital skill plays a significant role in connecting the teacher and students to available instructional content housed on the web as well as establishing interaction between the teacher and students irrespective of location. (Sánchez, 2024; Preston, 2024). The implication of this is that the use of digital tools in the training, upgrading, and re-training of technical college graduates is of paramount significance and an essential aspect of the cultural toolkit for teaching in the twenty-first century.

Determining technical administrators and employers' perceptions regarding the proposed strategies for improving the use of digital skills and AI in teaching technical college students to enhance employability and career engagement for economic diversification. The findings concerning the proposed strategies for improving the use of digital skills and AI agreed with the findings of Nkechinyere, Amos, and Chiedu (2022), who emphasized that a technology framework was needed to support digital tools. Suggested a policy point of view to develop a legal framework that assures equal rights for men and women in terms of gender equality. This will protect them from discriminatory practices and foster equitable participation in society and the economy by men and women. Furthermore, authorities should expect an improvement in teachers' attitudes toward adopting digital tools. This can be done by giving them the technology tools, training, and incentives they need to effectively use digital tools in the classroom for the benefit of their students (Erwin & Mohammed, 2022). The implication of this for technical college instructors is to ensure an increase in acceptance and adoption of the digital tools, expose students, and encourage collaboration with establishments to provide students with real-world projects, internships, and mentorship opportunities.

CONCLUSION AND RECOMMENDATIONS

Technical colleges were purposely established to empower its prospective graduates with the skills, knowledge, and attitudes necessary to succeed in their chosen or emerging careers, be employable, and make meaningful contributions to their societies. This distinctive feature of technical colleges, with the addition of digital tools as a mandatory component, makes technical college programmes more potent toward economic diversification. The present study examined career engagement and employability among technical college students through digital skills and AI for economic diversification. Based on the analysis presented in this paper, the paper draws its conclusion that digital skills and Artificial Intelligence are globally recognized attributes needed for Nigeria technical colleges to support learning as to enhance teaching and learning outcomes, also enabling individuals to thrive in the digital age aimed at developing a skilled workforce in a diversified economy. Adopting digital skills and AI, Nigeria's technical colleges could improve their effectiveness, offer personalized learning experiences to enhance technical college career engagement and employability. The government, through technical colleges/institutions and other agencies, should focus on using

digital tools for developing the digital skills of their graduates instead of learning about digital tools, as this can provide wider availability of best practices and best course materials in technical college. It was recommended that to acclimatize technical colleges to develop human resources for the ever-dynamic world of work, here is a need for the government and TVET stakeholders to focus investment in the use and equip technical colleges with up-to-date hardware, software, and internet connectivity to ensure students have access for practicing and facilitating digital learning, and employ AI-driven platforms to tailor learning experiences to meet individual needs, identify skill gaps, and recommend personalised resources for improvement. In conclusion, financial assistance should be given to technical institutions and students to acquire digital tools for practical use in the delivery of their courses and programmes and employ AI-driven platforms to tailor learning experiences to meet individual needs, identify skill gaps, and recommend personalised resources for improvement.

References

Abiwo, L; Olabiyi, O. S.; Olafare, F. & Odumuyiwa, V (2023). Teachers' acceptance of computer learning tools for teaching technical drawing in Lagos state technical colleges. *Industrial Technical Education Journal* (ITEJ) 5 (1), 43-50.

Acemoglu, D & Autor, D (2011). skills, tasks and technologies: implications for employment and earnings. Handbook of Labor **Economics**, volume 4.

Awofala, A.O.A., Olabiyi, O.S.**,** Awofala,A. A., Ojo, O.T., Okunuga, R.O. & Lawani, A.O. (2020) Investigating digital distraction among pre-service science, technology, and mathematics teachers in Nigeria. Digital Education Review- 37, 32-48

Becker, B. W. (2018). Information literacy in the digital age: Myths and principles of digital literacy. School of Information Student Research Journal, 7(2). Retrieved from http://scholarworks.sjsu.edu/slissrj/vol7/iss2/2

Bombard Y, Baker G. R, Orlando E, Fancott C, Bhatia P, Casalino S, Onate K, Denis J. L, Pomey M. P. (2018). Engaging patients to improve quality of care: a systematic review. Implement Sci. 26;13(1):98. doi: 10.1186/s13012-018-0784-z. PMID: 30045735; PMCID: PMC6060529.

Borthwick, A. C. & Hansen, R (2017) Digital Literacy in Teacher Education: Are Teacher Educators Competent? *Journal of Digital Learning in Teacher Education*, 33:2, 46-48, DOI: 10.1080/21532974.2017.1291249

Cherif, R. & Hasanov, F. (2019). Principles of True Industrial Policy. *Journal of Globalization and Development*, *10*(1), 20190034. https://doi.org/10.1515/jgd-2019-0034.

Corinne C. D., Giovanni M., Monique N., Chris P., Ke W., & Nikola, S. (2024). Economic diversification in developing countries: lessons from country experiences with broad-based and industrial policies. International Monetary Fund (006) https://doi.org/10.5089/9798400240201.087

Creswell. J.W. & Creswell, J.D. (2017) Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. 4th Edition, Sage, Newbury Park.

Dang, V. H. & Nguyen, T. T. (2024). The Impact of Formal and Non-Formal Training Programs inVietnam's Manufacturing Sector. In: TVET@Asia, issue 22, 1-17.

Erwin, K., & Mohammed, S. (2022). Digital literacy skills instruction and increased skills proficiency. International Journal of Technology in Education and Science (IJTES), 6(2), 323-332. https://doi.org/10.46328/ijtes.364

International Monetary Fund (IMF). (2015). "Sustaining Long-Run Growth and Macroeconomic Stability in Low-Income Countries—The Role of Structural Transformation and Diversification." *IMF Policy Paper*, Washington, DC.

International Monetary Fund Annual Report 2014: From stabilization to sustainable growth.

Kagaari, J. (2007). Evaluation of the effects of vocational choice and practical training on students' employability. *Journal of European Industrial Training 31(6):449-471 DOI: 10.1108/03090590710772640*

Lee, W. (2010). Skills for work, skills for life. I Can Talk Series, Issue 8

MacDonald, S., Nink, C., & Stephen Duggan, S. (2010). Building better formal TVETsystems: principles and practice in low- and middle- income countries. Online:https://www.mtctrains.com/wp-content/uploads/2017/06/Principles-and-Strategies-of-a-Successful-TVET-Program.pdf (retrieved 21.01.2024)

Maher, A., & Graves, S. (2008). Graduate employability: Can higher education deliver? Threshold Press.

Merriam, S. B., & Tisdell, E. J. (2015). Qualitative Research: A Guide to Design and Implementation. San Francisco, CA: Wiley.

Neault, R. A., & Pickerell, D. A. (2011). Career engagement: Bridging career counseling and employee engagement. Journal of Employment Counseling, 48(4), 185-188.

Neuman, W. L. (2014). Social Research Methods: Qualitative and Quantitative Approaches (7th ed.). Essex: Pearson.

Nkechinyere C. E., Amos N. A., & Chiedu, E. (2022). Gender Differences in Teachers' Digital Literacy Skills for Assisting Students with Functional Diversity. International Journal of Early Childhood Special Education (INT-JECSE) Vol 14, Issue 05

Ogunleye, A. O. (2000). An introduction to research methods in education and social sciences, Sunshine International Publications (Nig.) Ltd, Lagos.

Olabiyi, O. S & Olafare, F. O (2022). Utilization of Work-Based Learning Program to Develop Employability Skill of Workforce (Craftsmen) In Construction Industry Towards Industrial Development. *Indonesian Journal of Educational Research and Technology* 2(3)179-188.Available online at http://ejournal.upi.edu/index.php/IJERT/

Olabiyi, O. S. (2014). Challenges of using information communication technology (ICT) in Nigerian technical vocational education institutions. *International Journal of Educational Research and Development, 3*, 197-212.

Olabiyi, O. S. (2022). Improving architectural drawing students' achievement by coalescing computer-aided design with the compass method. INVOTEC XVII:2 138-152

Olabiyi, O. S., Okeowo, S. O., Adedayo, G. O., & Ipinlaye, A. (2022) Public-private partnership for effective delivery of technical vocational education in enhancing graduate employability skills during the era of Covid-19 pandemic in Nigeria. Jurnal Pendidikan Teknologi dan Kejuruan, 28(1), 01-13. https://doi.org/10.21831/jptk.v28i1.45519

Olabiyi, O.S., Ojo, B., Keshinro, O.T., & Okeowo, S.O (2020). Comparative effects of digital instructional video and PowerPoint presentation on academic achievement and

learning retention of basic technology students. *Journal of Educational Research on Children, Parents & teachers*, 1(1), 11-24.

Ottestad, G., Kelentrić, M., & Guðmundsdóttir, G. (2014). Professional digital competence in teacher education. Nordic Journal of Digital Literacy, 9(4), 243–249.

Papageorgiou, C., Spatafora, N., & Wang, K, (2015). Diversification, Growth, and Volatility in Asia (July 28, 2015). World Bank Policy Research Working Paper No. 7380, Available at SSRN: https://ssrn.com/abstract=2637111

Pickerell, D. A., & Neault, R. A. (2012). Where's the work? Helping career practitioners explore their career options. Aldergrove, BC: Life Strategies Ltd.

Pickerell, D.A., & Neault, R.A. (2019). Maximizing Career Engagement Across a Lifetime of Transitions. *Handbook of Innovative Career Counselling*.

Preston. R. (2024). What are digital skills, and why are they relevant in the world of work? https://www.indeed.com/career-advice/career-development/digital-skills.

Rothbard, N. P. (2001). Enriching or Depleting? The Dynamics of Engagement in Work and Family Roles. Administrative Science Quarterly, 46, 655-684. http://dx.doi.org/10.2307/3094827

Saks, A. M. (2006). Antecedents and consequences of employee engagement. Journal of Managerial Psychology, 21(7), 600–619. https:// https://doi.org/10.1108/02683940610690169. …

Sánchez, C. (2024). What are digital skills, and why are they relevant in the world of work?

PERCEIVED IMPACT OF DIGITAL TECHNOLOGY UTILIZATION ON TROUBLE-SHOOTING SKILL ENHANCEMENT AMONG STUDENTS IN ELECTRICAL ELECTRONIC TRADES IN TECHNICAL COLLEGES

By

Dr. Ukelabuchi Iloma,
Rivers State University, Port Harcourt
Faculty of Education, Department of Industrial Technology Education
Corresponding Contact: iloma.ukelabuchi@ust.edu.ng +2348038290739

Precious Chikobi Osoh
Federal College of Education (Technical), Omoku, Rivers State,
School of Secondary Education (Technical), Electrical Electronic Department
Preshchiko@gmail.com 08039925011

Abstract
This study determines respondents' perception on the impact of digital technology utilization on trouble-shooting skill enhancement among students in electrical electronic trades in technical colleges. The study adopted descriptive research design was carried out in Rivers State, Nigeria. The population is 127 subjects consisting of 22 teachers and 105 final students in electrical electronic trades in four purposively selected technical colleges in the State. The entire population was census sampled and used for the study due to its manageable size. A 20-item validated questionnaire with a reliability coefficient of 0.76 was used for data collection. Data collected was analyzed using mean statistics. Items with mean rating of 2.50 and above were regard as Agree while items with mean rating below 2.50 were regarded as Not Agree. Findings showed among others that respondents perceived to a high extent that the utilization of digital technology enhances trouble-shooting skills among students. Provision of digital tools was among the recommendations made.
Keynotes: Digital technology, trouble-shooting skill, electrical electronic, technical College

Introduction
Electrical electronic plays vital role in the socio-economic development of the society in this era of dynamic technological advancement. Many industries, homes, businesses and social outlets rely heavily on electrical electronic for successes, growth and satisfaction. Electrical and electronic gadgets encompass a wide array of devices that utilize electricity and electronic components to perform various functions. Functionality of electrical electronic system is essential for its optimal performance. As an essential aspect of good engineering practices, the importance of developing trouble-shooting skill to guarantee sustainable usability of electrical electronic devices is imperative. Technical college as an aspect of educational institution is also designed to achieve acquisition of several skills.

In line with this, UNESCO International Centre for Technical and Vocational Education and Training (UNEVOC, 2023) defined technical colleges as institutions that offer education and training for skills development, fostering employability and addressing labour market needs. National Board for Technical Education (NBTE, 2016) defined technical college as an educational institution that offers programmes that emphasize vocational and technical education, focusing on skills required for specific trades and professions.

The main goal of technical college is to equip learners with practical skills needed for employment and entrepreneurship (NBTE, 2012). Electrical electronic trades is among several trades offered in Technical Colleges in Nigeria. According to NBTE (2012), the trade

area consists of Appliances Maintenance and Repairs, Electrical Installations and Maintenance Works, Instrument Mechanics, Radio and Television, and Electronics Work. United Nations Educational, Scientific and Cultural Organization (UNESCO, 2021) states the aim of technical college to include acquisition of Trouble-shooting skill in electrical electronic instructions. Improving students proficiency and skill in electrical electronic through practical experiences is in line with the objective of technical education. According to the National Policy on Education of the Federal Republic of Nigeria (NPE,FRN,2013), technical college is one of the institutions for realizing the goals of Technical and Vocational Education and Training (TVET) which emphasizes acquisition of scientific knowledge and practical skills. Several skills could therefore be acquired in technical colleges of which maintenance and repairs skills is inclusive. Among others, skills enable individuals to generate wealth through gainful employment, improves job retention, and can also enhance successes as entrepreneur. Skill is the ability to acquire practical and scientific knowledge in a new condition which is built on previous experiences, exposures and abilities (Iloma & Ikenyiri, 2021). Skill is therefore potentials developed by a person through conscious effort which becomes automatic in terms of performing the required task in a matter of time.

Enhancing learners' skill on trouble-shooting could therefore be advantageous to the learner, companies and those who depend on electrical electronic for their business and comfort. Khandpur (2012) defined troubleshooting as a logical, systematic search for the source of a problem with the aim of solving the problem so that the product can perform its original function again. Beatriz, Conny, Bas and Ruud (2020) opined that trouble-shooting is essential step to product repair which encompasses the process of identifying and characterizing a fault when a failure occurs. Thus, trouble-shooting skill is the ability to identify and solve a problem in a system by applying systematic approach (Diong, Chin, Das, Tekes, & Thain, 2021). Trouble-shooting skill in electrical electronic trades is therefore the ability to identify problems in electrical electronic system, devices or gadget when failure occur and also solve such identified problem so that the system works again using logical and systematic approach within a specified time frame.

Since trouble shooting skill is essential in ensuring that faulty electrical electronic systems and gadgets are rectified for optimal performance, utilization of modern gadgets such as digital technological could be necessary in enhancing students' skill and proficiency in it. Digital technology is the addition of digital resources such as data, computing, and connectivity into desired process to enable innovation and transformation take place (Kraus *et al.*, 2021). Egodawele, Sedera and Bui (2021) opined that digital technology is transformative and has the ability to reshape the pattern in which individuals and institutions interact, communicate, and create value**.** Digital technologies could be valuable when combined with practical approach during classroom instruction in electrical electronic trades.

Al-Ali, Zualkernan and Aloul (2020) opined that utilization of digital tools such as simulation software and diagnostic applications help technicians identify faults more precisely which reduces trial-and-error approaches and its implications. For practicing fault diagnosis, Kumar, Sharma and Singh (2020) noted that the use of Augmented reality (AR) and virtual laboratories provide immersive environments for practicing fault diagnosis thereby enhancing learners' confidence and competence. AI-powered analytics has the ability of predicting potential failures before they occur, allowing technicians to intervene proactively and refine their troubleshooting strategies (Chen, Zhang & Wang, 2020). Several skills are required in trouble - shooting processes in electrical electronic trades. This include but not limited to skill in schematic interpretation, circuit analysis, component testing, visual inspection, signal tracing, fault isolation, knowledge of common failure, safety knowledge and documentation.

Several studies has shown that digital technology is not utilized in instructional process in technical colleges the resultant effect could hinder skill enhancement. For instance studies by

Oke and Oludele (2023) shows that personal computers and projectors were only slightly available and underutilized in technical colleges in Osun State. Also David (2014) emphasized that instructional delivery largely utilize non-digital methods in vocational and technical education in Nigeria. Several other studies such as that of Aduwa-Ogiegbaen and Iyamu (2005), Adu and Olatundun (2013) and Eze, Chinedu-Eze and Bello (2018) have shown that digital technology are mostly not available, but were available, it is always grossly underutilized in technical colleges in Nigeria. This situation could impact negatively on trouble-shooting skill enhancement among students. This study is therefore designed to determine the perception of respondents on the impact of digital technology utilization on trouble shooting skill enhancement among students in electrical electronic trades in technical colleges.

Purpose of the Study

The main purpose of this study is to determine the perception of respondents on the impact of utilization of digital technology on enhancing trouble-shooting skill among students in electrical electronic trades in technical colleges. Specifically, this study sought to determines the perception of respondents on the impact of digital technology on enhancing trouble shooting-skill in

1. schematic interpretation,
2. circuit analysis,
3. component testing
4. signal tracing

Research Questions

This study was guided by the following research questions

1. What is the perception of respondents on the impact of utilization of digital technology on enhancing schematic interpretation skill among students in electrical electronic trade?
2. What is the perception of respondents on the impact of utilization of digital technology on enhancing circuit analysis skill among students in electrical electronic trade?
3. What is the perception of respondents on the impact of utilization of digital technology on enhancing component testing skill among students in electrical electronic trade?
4. What is the perception of respondents on the impact of utilization of digital technology on enhancing signal testing skill among students in electrical electronic trade?

Method

This study explores the perception of respondents on the impact of digital technology utilization on enhancing trouble-shooting skills among students in electrical electronic trades in technical colleges. The study which was carried out in Rivers State, Nigeria, adopted descriptive research design. The total population was 127 subjects consisting of 22 teachers and 105 students in electrical electronic trades in four purposively selected technical colleges in the State. Census sampling was used to draw the entire population and used for the study because of its manageable size. A validated questionnaire with a reliability coefficient of 0.76 developed by the researchers was used for data collection. The instrument consisted of 20-items answerable on a four-point scale rating of Very High Extent (VHE), High Extent (HE), Low Extent (LE) and Very Low Extent (VLE) with numerical value of 4,3,2,1 respectively assigned. The instrument was administered on the respondents and retrieved on the spot after completion by the researchers and research assistants. Data collected was analyzed using mean statistics. Items with mean rating of 2.50 and above were regard as Agree while items with mean rating below 2.50 were regarded as Not Agree.

Results

Research Question 1

What is the perception of respondents on the impact of utilization of digital technology on enhancing schematic interpretation skill among students in electrical electronic trade?

Table 1: Mean ratings on **the** perception of respondents on the impact of utilization of digital technology on enhancing schematic interpretation skill among students in electrical electronic trade

SN	Items	VHE	HE	LE	VLE	Total	Mean	Decision
1	Students will exhibit better understanding of electrical schematics when taught using digital simulation tools	41	59	14	13	127	3.00	Agree
2	exposure of students to digital troubleshooting simulations will improve skill in schematic reading accuracy	62	38	16	11	127	3.18	Agree
3	The use of digital tools will make complex circuit diagram analysis and interpretation easier for students	71	31	15	10	127	3.29	Agree
4	The use of augmented or virtual reality applications in class will enhance students' confidence and competency in interpreting schematics	50	41	17	19	127	2.96	Agree
5	E-learning will enhance students' interest and retention of schematic symbols and functions	59	61	4	3	127	3.39	Agree
	Grand Mean						**3.16**	**Agree**

Table 1 showed that respondents agreed to each of the items of the instrument as the mean score of each of the items is above the cut-off point of 2.50. The overall mean of 3.16 showed that respondents perceived that utilization of digital technology to a high extent, impact on enhancing schematic interpretation skill among students in electrical electronic trades**.**

Research Question 2

What is the perception of respondents on the impact of utilization of digital technology on enhancing circuit analysis skill among students in electrical electronic trade?

Table 3: Mean ratings on the perception of respondents on the impact of utilization of digital technology on enhancing circuit analysis skill among students in electrical electronic trade

SN	Items	VHE	HE	LE	VLE	Total	Mean	Decision
6	The use of digital learning tools in learning will reduce the time needed by students to understand complex circuit configurations	31	64	19	13	127	2.89	Agree
7	The use of digital circuit simulators will enhance students' understanding of voltage, current, and resistance relationships in a circuit.	52	43	18	14	127	3.04	Agree
8	Utilization of digital oscilloscopes and multimeters in virtual laboratories will enhance students' analytical skills in circuit diagnostics	55	41	20	11	127	3.16	Agree
9	Students will show enhanced	45	42	26	14	127	2.93	Agree

	accuracy in solving circuit problems after using digital learning resources							
10	Students' logical reasoning in circuit analysis will be enhanced if real-time feedback through digital platforms is integrated in instructions.	59	51	9	8	127	3.27	Agree
	Grand Mean						**3. 05**	**Agree**

Table 2 showed that respondents agreed to each of the items of the instrument as the mean score of each of the items is higher than the cut-off point of 2.50. The overall mean of 3.05 showed that respondents perceived that utilization of digital technology to a high extent, positively impact on enhancing circuit analysis skill among students in electrical electronic trades in technical colleges in Rivers State**.**

Research Question 3

What is the perception of respondents on the impact of digital technology utilization on enhancing component testing skill among students in electrical electronic trade?

Table 3: Mean ratings on the perception of respondents on the impact of utilization of digital technology on enhancing component testing skill among students in electrical electronic trades

SN	Items	VHE	HE	LE	VLE	Total	Mean	Decision
11	Students will troubleshoot faulty components more effectively after using digital testing simulations for practicing.	36	60	14	17	127	2.91	Agree
12	utilization of digital platforms will enable students to test components repeatedly until the process is mastered.	42	48	20	17	127	2.90	Agree
13	Interactive e-tutorials will enhance students' skill in identifying faulty components	55	41	20	11	127	3.10	Agree
14	Utilization of digital multi-meter simulation tools will enhance students skill in testing electronic components.	41	42	26	18	127	2.83	Agree
15	integration of digital technologies will boosts students' interest and retention in component testing	50	51	13	13	127	3.08	Agree
	Grand Mean						**2.96**	**Agree**

Table 3 showed that respondents agreed to each of the items of the instrument as the mean score of each of the items is higher than 2.50. The overall mean of 1.96 showed that respondents perceived that utilization of digital technology to a high extent, positively impact on enhancing component testing skill among students in electrical electronic trades.

Research Question 4

What is the perception of respondents on the impact of utilization of digital technology on enhancing signal testing skill among students in electrical electronic trade?

Table 4: Mean rating on the perception of respondents on the impact of utilization of digital technology on enhancing signal testing skill among students in electrical electronic trade

SN	Items	VHE	HE	LE	VLE	Total	Mean	Decision
16	Signal simulation software will enhance students' understanding of waveform characteristics	41	42	26	18	127	2.83	Agree
17	Augmented or virtual reality tools will boosts students' fault-diagnosis skills if they are used for practicing signal tracing	50	41	17	19	127	2.96	Agree
18	digital oscilloscopes in practical lessons will enhance students' ability to analyze electrical signals.	55	38	21	13	127	3.06	Agree
19	Students will perform better if they are regularly engaged with digital signal testing platforms	52	43	18	14	127	3.04	Agree
20	Practicing with digital signal analyzers will make it easier for students to distinguish between different signal types	71	31	15	10	127	3.29	Agree
	Grand Mean						**3. 04**	**Agree**

Result as analyzed in Table 4 shows that respondents agree to each of the items of the instrument as the mean of each of the items is above the cut-off point of 2.50. The overall grand mean of 3.04 implies that it is the perception of respondents that utilization of digital technology to a high extent, enhances signal testing skill among students in electrical electronic trade which is one of the trouble-shooting skills in electrical electronic trades.

Discussion

Table 1 showed that respondents perceived that the use of digital technology will enhance students' skill schematic interpretation skill among students in electrical electronic trades. This finding is in line with that of Al-Ali, Zualkernan and Aloul (2020) that utilization of digital tools such as simulation software and diagnostic applications help technicians identify faults more precisely which reduces trial-and-error approaches and its implications. Table 2 showed that respondents perceived that utilization of digital technology to a high extent, positively impact on enhancing circuit analysis skill among students in electrical electronic trades in technical colleges. This finding agrees with that of Kumar, Sharma and Singh (2020) that the use of Augmented reality (AR) and virtual laboratories provide immersive environments for practicing fault diagnosis thereby enhancing learners' confidence and competence. Table 3 showed that respondents perceived that utilization of digital technology to a high extent, positively impact on enhancing component testing skill among students in electrical electronic trades. The finding corroborates that of Egodawele, Sedera and Bui (2021) that digital technology is transformative and has the ability to reshape the pattern in which individuals and institutions interact, communicate, and create value. Table 4 showed that it is the perception of respondents that utilization of digital technology to a high extent, enhances signal testing skill among students in electrical electronic trade which is one of the trouble-shooting skills in electrical electronic trades. This is in line with the findings of Chen, Zhang and Wang (2020) that AI-powered analytic has the ability of predicting potential

failures before they occur, allowing technicians to intervene proactively and refine their troubleshooting strategies.

Recommendations

Based on the findings of this study, the following recommendations were made

1. Digital tools such as smart board Augmented Realities, computers should be provided by government and non-governmental organizations

2. Teachers should be adequately trained on the use of digital technology in instructional processes

3. Students be provided with equipped e-laboratories for effective learning

4. Classrooms and workshops should be digitized

References

Adu, E. O., & Olatundun, S. A. (2013). The use and management of ICT in schools: Strategies for school leaders. *European Journal of Computer Science and Information Technology*, 1(2), 10–16.

Aduwa-Ogiegbaen, S. E., & Iyamu, E. O. S. (2005). Using information and communication technology in secondary schools in Nigeria: Problems and prospects. *Educational Technology & Society*, 8(1), 104–112.

Al-Ali, A. R., Zualkernan, I. A., & Aloul, F. (2020). A mobile GPRS-sensors array for air pollution monitoring. *IEEE Sensors Journal*, *20*(3), 1455–1462. https://doi.org/10.1109/JSEN.2019.2949988

Beatriz, P.A, Conny, B., Bas, F., Ruud, B.(2020). Practices of fault diagnosis in household appliances: Insights for design. *Journal of Cleaner Production* 265 (2020) 121812

Chen, X., Zhang, Y., & Wang, J. (2020). Intelligent fault diagnosis method for rotating machinery using digital twin and deep transfer learning. *IEEE Access*, *8*, 123146–123156. https://doi.org/10.1109/ACCESS.2020.3007254

David, S. (2014). An overview of vocational and technical education in Nigeria under secondary school education system. *International Journal of Technology Enhancements and Emerging Engineering Research*, 2 (6), 119–122.

Diong, B. M., Chin, C. A., Das, S., Tekes, A., & Thain, W. (2021). Enhancing Engineering Students' Troubleshooting Skills Paper presented at 2021 ASEE Virtual Annual Conference Content Access, Virtual Conference. 10.18260/1-2--37083

Egodawele, M., Sedera, D., & Bui, V. (2021). A systematic review of digital transformation literature (2013–2021) and the development of an overarching a-priori model. *arXiv preprint*.

Eze, S. C., Chinedu-Eze, V. C., & Bello, A. O. (2018). The utilization of e-learning facilities in the educational delivery system of Nigerian universities. *International Journal of Educational Technology in Higher Education,* 15 (34). https://doi.org/10.1186/s41239-018-0116-z

Iloma, U. & Ikenyiri P. N. (2021). Scaling up entrepreneurship in TVET for poverty eradication and sustainable national development. *Annals of Technology Education Practitioners Association of Nigeria* 4(1), 11-17

Khandpur, A. (2012). Troubleshooting Electronic Equipment: Includes Repair and Maintenance.*Retrieved on 3/6/2023 from https://www.accessengineeringlibrary.com.-second-edition.*

Kumar, A., Sharma, S., & Singh, R. (2020). Augmented reality-based training system for electrical maintenance. *International Journal of Electrical Engineering Education*, *57*(4), 345–360. https://doi.org/10.1177/0020720919874567

Kuphaldt, T. R. (2015). Reference lessons in electric circuits. *Retrieved* on *13/05/2023 from https://www.allaboutcircuits.com/textbook/reference/chpt-8/specific-troubleshooting-techniques/*

Kraus, S., Jones, P., Kailer, N., Weinmann, A., Chaparro-Banegas, N., & Roig-Tierno, N. (2021). Digital transformation: An overview of the current state of the art of research. *SAGE Open*, 11(3), 1–15. https://doi.org/10.1177/21582440211047576

National Board for Technical Education (2012). List of programmes. Retrieved from C:\Users\Hp\Downloads\National Board for Technical Education (NBTE) list of programmes .htm

National Board for Technical Education (NBTE). (2016). Strategic Plan for the Development of Technical and Vocational Education and Training in Nigeria

Noe, R. A. (2010). Emloyee Training and Development. McR\Graw.Hill

Oke, J. O., & Oludele, L. Y. (2023). Availability and utilization of paperless technology among staff of technical colleges in Osun State, Nigeria. *Journal of Contemporary Issues and Thought,* 13 (2). https://doi.org/10.37134/jcit.vol13.2.3.2023

United Nations Educational, Scientific and Cultural Organization (UNESCO, 2012). Learning for Work, Life and a Sustainable Future: National Vocational Education and Training (VET) Policy Development. UNESCO

UNEVOC. (2013). Guidelines for the Development of Technical and Vocational Education and Training (TVET) Institutions. UNIVOC

LEVERAGING DIGITAL SKILLS AND AI FOR ENTREPRENEURIAL INNOVATION IN TVET: PATHWAY TO WEALTH AND JOB CREATION IN THE 21ST CENTURY

[1]Shodeinde A. O.,[2]Ganthonu J.O., [3]Adekunle O.A.,[3]Ajala O.S., & [4]Ogunnowo T.A

[1] Department of Industrial Technical Education, Tai Solarin University of Education, Ijagun, Ogun State
[2]College of Information and Technology Education, Department of Electrical and Electronics Education, Lagos State University of Education, Otto/Ijanikin (Epe Campus), Lagos State
[3]College of Vocational and Entrepreneurship Education, Department of Agricultural Science Education, Lagos State University of Education, Otto/Ijanikin (Epe Campus), Lagos State
[3]College of Vocational and Entrepreneurship Education, Department of Agricultural Science Education, Lagos State University of Education, Otto/Ijanikin (Epe Campus), Lagos State
[4]College of Vocational and Entrepreneurship Education, Department of Entrepreneurial Education, Lagos State University of Education, Otto/Ijanikin (Epe Campus), Lagos State

Abstract

This study explored integrating digital skills and artificial intelligence (AI) into Technical and Vocational Education and Training (TVET) to foster entrepreneurial innovation, wealth, and job creation, addressing outdated curricula limiting students' potential. Conducted at Lagos State University of Education, Oto-Ijanikin and Epe campuses, Nigeria, it targeted 4,500 TVET students in Electrical/Electronics and Agricultural Technology. A descriptive survey design was used, with purposive sampling of 150 respondents (100 students, 50 instructors). Data were collected via a 30-item questionnaire (LDSATEIFWJ) on a 4-point Likert scale (reliability: 0.82 Cronbach's Alpha). Mean and standard deviation were applied (benchmark: 2.50), revealing grand means of 3.33, 3.31, and 3.34. The 3.33 mean confirms digital skills like coding and IoT enable innovation, supporting startups in smart devices and farm apps. The 3.31 mean indicates AI competencies, such as machine learning, drive wealth-generating ventures in agriculture and electronics. The 3.34 mean highlights strategies like industry-aligned curricula and partnerships for job creation. In conclusion, digital skills and AI are vital for TVET-driven entrepreneurship, enhancing 21st-century economic diversification. TVET institutions should modernize curricula to include digital skills (e.g., coding, IoT) and AI competencies (e.g., machine learning) tailored to Electrical/Electronics and Agricultural Technology, foster public-private partnerships for AI labs, mentorship, and funding, and invest in infrastructure (e.g., internet, AI tools) for equitable access. Additionally, continuous instructor training, collaborative platforms for knowledge exchange, and regular curriculum reviews aligned with market trends should be prioritized to sustain relevance and innovation.

Keywords: Digital Skills , Artificial Intelligence , TVET , Entrepreneurial Innovation , Wealth and Job Creation

Introduction

The 21st-century economy demands a workforce proficient in digital technologies and artificial intelligence (AI) to spur innovation and economic diversification. Technical and Vocational Education and Training (TVET) is pivotal in providing practical, industry-aligned skills, particularly in fields like Electrical/Electronics and Agricultural Technology (Mustaffa *et al.,* 2024; Hani *et al.,* 2024; Riyanda *et al.,* 2021). By incorporating digital tools such as the

Internet of Things (IoT) and data analytics, alongside AI technologies like machine learning and automation, TVET transforms traditional practices, creating opportunities for entrepreneurial ventures in these sectors (Bonde, 2024; Amdan *et al.,* 2024). This integration not only enhances skill development but also aligns TVET with industry demands, fostering sustainable economic growth.

TVET educators face challenges in adapting to digitization, requiring them to develop digital competencies to effectively integrate technology into teaching (Hani *et al.,* 2024). In Malaysia, government initiatives underscore the importance of digital integration in education, mirroring global trends (Hani *et al.,* 2024). Embedding digital entrepreneurship within TVET curricula is essential to equip students for digital ventures (Mustaffa *et al.,* 2024). Emerging technologies like AI, IoT, virtual reality (VR), and augmented reality (AR) are reshaping TVET by improving skill acquisition through personalized learning tools, such as adaptive algorithms and virtual simulations, catering to diverse learners in Malaysian TVET institutions (Amdan *et al.,* 2024; Bonde, 2024).

Digital transformation is revolutionizing multiple sectors. In agriculture, technologies like IoT, AI, blockchain, and robotics enhance efficiency, food safety, and sustainability, with AI-powered drones enabling precision farming through data-driven crop management (Konfo *et al.,* 2023; Lassoued *et al.,* 2023). In manufacturing, Industry 4.0 technologies, including cyber-physical systems and digital twins, promote automation and sustainability (Jamwal *et al.,* 2021; Tiwari, 2023). Maritime logistics is also adopting digital solutions to improve efficiency, though progress is slow in some areas (Raza *et al.,* 2023). These developments emphasize the need for TVET to align with industry demands.

The integration of digital skills and AI in TVET presents opportunities and challenges. AI streamlines workflows in sectors like education and manufacturing, necessitating new skill sets (Babashahi *et al.,* 2024). However, the digital divide, marked by limited connectivity and literacy, hinders AI and IoT adoption, particularly in agriculture (Delfani *et al.,* 2024). Ethical considerations, such as transparency and privacy in AI use, are vital for TVET institutions (Xiao, 2024). Many organizations remain at early stages of digital maturity, requiring significant investment in AI and analytics (Carayannis *et al.,* 2024). TVET must embed digital and AI competencies to prepare graduates for innovation and entrepreneurship (Rama *et al.,* 2024; Pongpith *et al.,* 2021).

TVET is critical in equipping the workforce with digital and AI skills for the 21st-century economy, fostering innovation in Electrical/Electronics and Agricultural Technology (Ogur, 2023). Industry collaboration ensures graduates have market-relevant skills for employment and entrepreneurship (Oviawe *et al.,* 2017). AI-driven tools, like learning analytics and VR/AR, enhance skill acquisition (Thakur *et al.,* 2024). Despite the potential of Information and Communication Technologies (ICT) to modernize TVET, adoption is limited in areas like teacher training, necessitating greater focus on IoT and data science (Hassan *et al.,* 2021). Innovative teaching methods, such as problem-based and blended learning, prepare students with digital literacy and entrepreneurial skills (Varma & Malik, 2024). However, challenges in integrating digital and AI technologies persist, requiring partnerships among educators, industries, and policymakers.

This study is justified by the urgent need to bridge the skills gap in TVET to meet the demands of the 21st-century digital economy, particularly in Nigeria's context, where outdated curricula limit entrepreneurial potential in Electrical/Electronics and Agricultural Technology. By examining how digital skills and AI can foster entrepreneurial innovation, the research provides empirical evidence to guide curriculum reforms and policy interventions at institutions like Lagos State University of Education. Addressing these gaps is critical to empowering TVET graduates to launch startups, create jobs, and contribute to economic

diversification, aligning with global trends in sustainable development and technological advancement.

Statement of the Problem

Technical and Vocational Education and Training (TVET) in Nigeria, particularly at institutions like Lagos State University of Education, Oto-Ijanikin and Epe campuses, currently faces significant challenges in fostering entrepreneurial innovation. Many TVET programs in Electrical/Electronics and Agricultural Technology rely on outdated curricula that emphasize traditional skills, limiting students' exposure to modern technologies and entrepreneurial competencies. The present state of TVET is characterized by insufficient integration of digital tools and a lack of focus on innovation-driven entrepreneurship, resulting in graduates who are ill-equipped to launch startups or address market demands. This contributes to high unemployment rates and a reliance on conventional sectors, stifling economic diversification and innovation in Nigeria's 21st-century economy.

With the integration of digital skills, such as coding, IoT, and data analytics, and AI competencies, including machine learning and automation, TVET could transform into a dynamic platform for entrepreneurial innovation. Students in Electrical/Electronics could develop smart devices, such as IoT-based sensors, while those in Agricultural Technology could create AI-driven precision farming tools, launching startups that generate wealth and jobs .Such a TVET system would align with Industry 4.0 demands, empower graduates to address local and global challenges, and drive economic diversification by fostering a vibrant entrepreneurial ecosystem. However, the absence of these technologies in current TVET programs prevents the realization of this potential, leaving a critical gap in Nigeria's workforce development.

The present study seeks to bridge this gap by providing empirical evidence on how digital skills and AI can enhance TVET programs to foster entrepreneurial innovation at Lagos State University of Education. By assessing the role of digital skills and AI competencies and identifying strategies for curriculum enhancement, the study aims to guide reforms that align TVET with the vision outlined above. Through stakeholder insights from students and instructors, the research will propose actionable interventions, such as industry partnerships and AI labs, to empower TVET graduates to launch innovative startups in Electrical/Electronics and Agricultural Technology, thereby contributing to wealth creation, job opportunities, and economic diversification in Nigeria's 21st-century economy

Purpose of the Study

The study aims to:

i. Assess the extent to which digital skills in TVET programs support entrepreneurial innovation in Electrical/Electronics and Agricultural Technology in tertiary institutions in Lagos State.
ii. Evaluate the role of AI competencies in enabling TVET students to create wealth-generating startups in tertiary institutions in Lagos State.
iii. Identify strategies for enhancing TVET curricula to foster job creation through entrepreneurial ventures in tertiary institutions in Lagos State.

Research Questions

i. To what extent do digital skills in TVET programs support entrepreneurial innovation in Electrical/Electronics and Agricultural Technology in tertiary institutions in Lagos State?
ii. How do AI competencies enable TVET students to create wealth-generating startups in tertiary institutions in Lagos State?
iii. What strategies can enhance TVET curricula to foster job creation through entrepreneurial ventures in tertiary institutions in Lagos State?

Methodology

The methodology for the study on integrating digital skills and AI into TVET at Lagos State University of Education, Oto-Ijanikin and Epe campuses, Nigeria, utilized a descriptive survey design to examine perceptions of entrepreneurial innovation, wealth, and job creation among 4,500 TVET students in Electrical/Electronics and Agricultural Technology. A purposive sample of 150 respondents (100 students, 50 instructors) was selected, and data were collected using a 30-item questionnaire (LDSATEIFWJ) on a 4-point Likert scale, validated by three experts and with a reliability of 0.82 (Cronbach's Alpha). Data, collected over March–April 2023, achieved a 95% return rate and were analyzed using mean and standard deviation (benchmark: 2.50) via SPSS version 26. Ethical measures included informed consent, anonymity, and secure data storage, ensuring compliance with the university's ethics guidelines.

Results and Discussion

Research question 1

To what extent do digital skills in TVET programs support entrepreneurial innovation in Electrical/Electronics and Agricultural Technology in tertiary institutions in Lagos State?

Table 1: Mean responses of respondents Extent to Which Digital Skills Support Entrepreneurial Innovation

S/N	Item Statement	Mean	SD	Decision
1	Coding skills enable startup app development.	3.45	0.65	Agree
2	IoT training supports smart device creation.	3.38	0.70	Agree
3	Data analytics aids market analysis for startups.	3.30	0.68	Agree
4	Digital marketing skills boost startup visibility.	3.50	0.62	Agree
5	Cybersecurity training protects startup data.	3.25	0.75	Agree
6	Cloud computing enhances startup scalability.	3.20	0.72	Agree
7	Digital skills reduce startup operational costs.	3.28	0.69	Agree
8	TVET digital training aligns with industry needs.	3.15	0.78	Agree
9	Digital tools foster collaborative innovation.	3.35	0.66	Agree
10	Digital skills empower youth entrepreneurship.	3.40	0.64	Agree
Grand Mean		3.33	0.69	Agree

The grand mean of 3.33 indicates strong agreement that digital skills support entrepreneurial innovation. High mean scores for digital marketing (3.50) and coding (3.45) suggest these skills are critical for launching startups in Electrical/Electronics (e.g., IoT devices) and Agricultural Technology (e.g., farm management apps). The low standard deviation (0.69) reflects consensus among respondents.

Research question 2

How do AI competencies enable TVET students to create wealth-generating startups in tertiary institutions in Lagos State?

Table 2: Mean responses of respondents Role of AI Competencies in Wealth-Generating Startups

S/N	Item Statement	Mean	SD	Decision
1	AI training enables precision farming tools.	3.42	0.67	Agree
2	Machine learning skills support predictive analytics.	3.35	0.70	Agree
3	Robotics knowledge aids automated systems.	3.30	0.73	Agree
4	AI-driven diagnostics enhance product reliability.	3.28	0.69	Agree
5	AI skills attract startup funding.	3.25	0.75	Agree
6	AI tools optimize startup supply chains.	3.20	0.72	Agree

7	AI competencies reduce startup risks.	3.18	0.78	Agree
8	AI training fosters innovative business models.	3.32	0.66	Agree
9	AI skills create competitive startup advantages.	3.38	0.68	Agree
10	AI empowers wealth creation via startups.	3.40	0.65	Agree
Grand Mean		3.31	0.70	Agree

The grand mean of 3.31 confirms that AI competencies enable wealth-generating startups. High scores for precision farming tools (3.42) and predictive analytics (3.35) highlight AI's relevance in agriculture and electronics. The standard deviation (0.70) indicates consistent agreement, suggesting AI skills are perceived as vital for startup success.

Research question 3

How do AI competencies enable TVET students to create wealth-generating startups in tertiary institutions in Lagos State?

Table 3: Mean responses of respondents on the Strategies to Enhance TVET Curricula for Job Creation

S/N	Item Statement	Mean	SD	Decision
1	Industry-aligned curricula foster job creation.	3.48	0.64	Agree
2	AI labs enhance practical training.	3.40	0.68	Agree
3	Public-private partnerships provide resources.	3.45	0.66	Agree
4	Entrepreneurship modules boost startup skills.	3.38	0.70	Agree
5	Open-source AI tools reduce training costs.	3.30	0.73	Agree
6	Virtual simulations improve skill acquisition.	3.25	0.75	Agree
7	Mentorship programs support startup launches.	3.28	0.69	Agree
8	Funding access aids entrepreneurial ventures.	3.35	0.67	Agree
9	Regional TVET hubs drive innovation.	3.20	0.72	Agree
10	Lifelong learning ensures skill relevance.	3.32	0.68	Agree
Grand Mean		3.34	0.69**	Agree**

The grand mean of 3.34 indicates agreement on strategies to enhance TVET curricula. Industry-aligned curricula (3.48) and public-private partnerships (3.45) scored highest, emphasizing the need for collaboration and relevance. The standard deviation (0.69) suggests consensus, reinforcing the feasibility of these strategies for job creation.

Discussion

The findings in Table 1 indicate that there is a strong consensus on the central role of coding and digital marketing in entrepreneurial innovation in disciplines like Electrical/Electronics and Agricultural Technology. With their average scores being 3.45 for coding and 3.50 for digital marketing, these skills are recognized as key to startup success, especially in leading-edge fields such as IoT and farm management applications ("Competencias digitales clave en el emprendimiento juvenil: una revisión sistemática de los últimos 6 años", 2023). The low standard deviation of 0.69 also highlights the strong agreement among respondents on the significance of these skills. Digital technology not only facilitates innovation by enabling entrepreneurs to identify and develop opportunities, reconfiguring traditional business processes (Ojala, 2024), but also facilitates entrepreneurship education by equipping students with necessary skills for successful business management (Sulistianingsih, 2023). However, alternative perspectives hold that core entrepreneurial skills such as leadership and money management remain just as vital,

suggesting a similar equilibrium between traditional entrepreneurial skills and digital technology for full startup success.

The findings from Table 2 with a grand mean of 3.31, indicated the prevailing consensus in terms of the critical role of AI capabilities in wealth-generating startups, particularly electronics and agriculture. Most interesting are high scores for precision farming technology (3.42) and predictive analytics (3.35), highlighting AI's transformative role in these sectors with an identical standard deviation of 0.70 affirming widespread stakeholder agreement on the necessity of these capabilities to thrive in startups. In farming, precision agriculture with AI leverages drones and IoT sensors for real-time monitoring of crops, optimizing the use of resources and raising productivity (Kacho *et al.,* 2024; Gupta, 2025), while predictive analytics based on machine learning enables farmers to predict crop yields and detect diseases in advance in order to take informed decisions (Azharuddin *et al.,* 2024; Kulkarni, 2024). In electronics, AI complements smart systems to optimize efficiency and align with overall digital transformation trends (Kulkarni, 2024). But despite these advancements, problems such as high capital cost, ethical concerns on the basis of data privacy, and potential effects on employment have to be addressed as AI continues to advance ("Impact of artificial intelligence in farming", 2024)

The findings in Table 3 indicated a high level of consensus on enhancing Technical and Vocational Education and Training (TVET) curricula through mechanisms like industry alignment and public-private partnerships with a grand mean of 3.34. Industry-aligned curricula (3.48) and public-private partnerships (3.45) are particularly emphasized by stakeholders as crucial in stimulating job creation and partnership. Industry interaction is crucial for curriculum designing to meet contemporary job demands and technological innovation, while enabling TVET institutions to react to evolving labor market needs and equipping graduates with relevant capabilities (Mustapha *et al.*, 2023; Njengele *et al.*, 2024). Public-private partnerships also enhance TVET through easier investment, improved delivery of services, and the availability of resource sharing, as well as the creation of access to financing and mentorship for TVET-driven start-ups (Baraya & Aliyu, 2014; Eze and Okoli, 2021; Rajamanickam *et al.,* 2024). Implementation may be hindered by problems such as opposition from traditional systems of education and uneven industry participation, though. Despite these obstacles, integrating digital and AI technologies remains vital for nurturing entrepreneurial ecosystems within TVET.

Conclusion

This study confirms that digital skills and AI competencies in TVET programs significantly support entrepreneurial innovation, wealth creation, and job creation in Electrical/Electronics and Agricultural Technology. The findings highlight the importance of modernizing curricula, leveraging AI tools, and fostering industry partnerships. By equipping students with these skills, TVET can drive economic diversification and empower youth to address 21st-century challenges through entrepreneurship.

Recommendations

i. TVET institutions should modernize curricula to include digital skills (e.g., coding, IoT) and AI competencies (e.g., machine learning) tailored to Electrical/Electronics and Agricultural Technology.
ii. Governments and TVET institutions should foster public-private partnerships to provide AI labs, mentorship, and funding for student startups.
iii. Policymakers should invest in infrastructure (e.g., internet, AI tools) to ensure equitable access to digital and AI training in TVET programs.

References

Androutsopoulou, M., Askounis, D., Carayannis, E. G., & Zotas, N. (2024). Leveraging AI for Enhanced eGovernment: Optimizing the Use of Open Governmental Data. *Journal of the Knowledge Economy*. https://doi.org/10.1007/s13132-024-02317-

Babashahi, L., Barbosa, C. E., Lima, Y., Lyra, A., Salazar, H., Argôlo, M., Almeida, M. A. de, & Souza, J. M. de. (2024). AI in the Workplace: A Systematic Review of Skill Transformation in the Industry. *Administrative Sciences*, 14(6), 127. https://doi.org/10.3390/admsci14060127

Baraya, U., & Aliyu, A. (2014). *Strategiesfor improving technical vocational educa tion and training fortheenhancement ofpublic- private partnership forsustainable industrial development of nigeria*.

Bonde, L. (2024). A Framework for Integrating Emerging Technologies into Technical and Vocational Education and Training. Africa *Journal of Technical and Vocational Education and Training*, 9(1), 97–107. https://doi.org/10.69641/afritvet.2024.91184

Competencias digitales clave en el emprendimiento juvenil: una revisión sistemática de los últimos 6 años. (2023). *Revista Interuniversitaria de Investigación En Tecnología Educativa*, 28–44. https://doi.org/10.6018/riite.565401

Gupta, N. (2025). Multidimensional and Revolutionary Relevance of AI in Agriculture. *Advances in Environmental Engineering and Green Technologies Book Series*, 145 174. https://doi.org/10.4018/979-8-3693-7483-2.ch006

Hassan, R. H., Hassan, M. T., Naseer, S., Khan, Z., & Jeon, M. (2021). ICT Enabled TVET Education: A Systematic Literature Review. *IEEE Access*, *9*, 81624–81650. https://doi.org/10.1109/ACCESS.2021.3085910

Impact of artificial intelligence in farming. (2024). *International Research Journal of Modernization in Engineering Technology and Science*. https://doi.org/10.56726/irjmets48807

Jamwal, A., Agrawal, R., Sharma, M., & Giallanza, A. (2021). Industry 4.0 Technologies for Manufacturing Sustainability: A Systematic Review and Future Research Directions. *Applied Sciences*, 11(12), 5725. https://doi.org/10.3390/app11125725

Kacho, N. F., Hussain, M. Y., & Banday, S. (2024). *Artificial intelligence in agriculture* (pp. 652–658). https://doi.org/10.58532/v3bcagp1ch51

Konfo, T. R. C., Djouhou, F. M. C., Hounhouigan, M. H., Dahouenon-Ahoussi, E., Avlessi, F., & Sohounhloue, C. K. D. (2023). Recent advances in the use of digital technologies in agri-food processing: A short review. *Applied Food Research*, 3(2), 100329. https://doi.org/10.1016/j.afres.2023.100329

Kulkarni, C. (2024). Transformation of Agriculture through Artificial Intelligence: A Comprehensive Review. *Journal of Scientific Research and Reports*, *30*(12), 798–803. https://doi.org/10.9734/jsrr/2024/v30i122722

Lassoued, R., Phillips, P. W. B., & Smyth, S. J. (2023). Exploratory analysis on drivers and barriers to Canadian prairie agricultural technology innovation and adoption. *Smart Agricultural Technology*, 5, 100257. https://doi.org/10.1016/j.atech.2023.100257

Md Hani, M. H., Ismail, A., Razali, S. S., Abu Bakar, M. N., Rosman, N. L., Nasir, N., & Mohamad, Z. (2024). The Development of Digital Competence Model Among TVET Educators Towards Digitization: A Concept Paper. *Journal of TVET And Technology Review*, 2(1). https://doi.org/10.30880/jttr.2024.02.01.001

Mohammad Aniq Bin Amdan, Naldo Janius, Mohd Norhazli Bin Jasman, & Mohd Aidil Hazidi Bin Kasdiah. (2024). Advancement of ai-tools in learning for technical vocational education and training (TVET) in Malaysia (empowering students and tutor). *International Journal of Science and Research Archive*, 12(1), 2061–2068. https://doi.org/10.30574/ijsra.2024.12.1.0971

Mustaffa, M., Mohd Tawil, N., S. Selvaratnam, D. P., Techanamurthy, U., & Mohd Affandi, H. (2024). Empowering Digital Entrepreneurship in Technical and Vocational Education and Training (TVET) Education. *Jurnal Kejuruteraan*, 36(4), 1459–1466. https://doi.org/10.17576/jkukm-2024-36(4)-11

Mustapha, A., Saari, A., & Jalaludin, N. A. (2023). Challenges and Collaboration Strategy of Industry in the Development of IR4.0 Skills for TVET. *International Journal of Academic Research in Progressive Education and Development*. https://doi.org/10.6007/ijarped/v12-i3/19001

Njengele, T., Engel-Hills, P., & Winberg, C. (2024). Technical and vocational education and training (TVET) colleges and industry: Strengthening partnership-building practices. *Journal of Vocational, Adult and Continuing Education and Training*, *7*(2), 23. https://doi.org/10.14426/jovacet.v7i2.418

Ogur, E. O. (2023). TVET, economy and sustainable development. *International Journal of Technical and Vocational Education*, *15*(2), 12–17. https://doi.org/10.5897/ijvte2022.0315

Ojala, A. (2024). *Digital Entrepreneurship*. Elsevier BV. https://doi.org/10.1016/b978-0-44313701-3.00035-9

Oviawe, J. I., Uwameiye, R., & Uddin, P. S. O. (2017). *Bridging Skill Gap to Meet Technical, Vocational Education and Training School-Workplace Collaboration in the 21 st Century*. *3*(1), 7. https://doi.org/10.11648/J.IJVETR.20170301.12

Sulistianingsih, S. (2023). Use of Digital Technology to Support the Entrepreneurship Education Process. *Indo-MathEdu Intellectuals Journal*. https://doi.org/10.54373/imeij.v4i2.203

Rama, A., Ambiyar, A., Lapisa, R., & Verawardina, U. (2024). Vocational Technology Education Innovation: Building a Generation of Experts in the Digital Age. Jurnal EDUCATIO: *Jurnal Pendidikan Indonesia*, 9(2), 1079. https://doi.org/10.29210/1202323361

Rajamanickam, S., Rus, R. C., Raji, M. N. A., Mina, H., & Vebrianto, R. (2024). Enhancing TVET Education for the Future: A Comprehensive Review of Strategies and Approaches. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, 69–89. https://doi.org/10.37934/araset.56.1.6989

Riyanda, A. R., Jalinus, N., Abdullah, R., Ranuharja, F., Islami, S., Adi, N. H., & Aminuddin, F. H. (2021). The New Paradigm of Technical and Vocational Education and Training (TVET). EDUKATIF : *JURNAL ILMU PENDIDIKAN*, 4(1), 364–371. https://doi.org/10.31004/edukatif.v4i1.1745

Thakur, G. S. M., Banerjee, A., & Sarkar, P. (2024). AI in Vocational Education and Training. *Advances in Educational Technologies and Instructional Design Book Series*, 49–72. https://doi.org/10.4018/979-8-3693-8252-3.ch003

Tiwari, S. (2023). Smart warehouse: A bibliometric analysis and future research direction. *Sustainable Manufacturing and Service Economics*, 2, 100014. https://doi.org/10.1016/j.smse.2023.100014

Tuenpusa, P., Boonpoo, S., & Chaisuk, P. (2021). Technical Vocational Education and Training (TVET) Workforce Skill Development Policy and Strategy to Support 4th Industrial Revolution due to Disruptive Technology. *Journal of Human Resource and Sustainability Studies*, 09(04), 596–607. https://doi.org/10.4236/jhrss.2021.94037

Varma, C., & Malik, S. (2024). *TVET in the 21st Century: A Focus on Innovative Teaching and Competency Indicators*. IntechOpen. https://doi.org/10.5772/intechopen.112516

PROJECT AND RESOURCE MANAGEMENT COMPETENCIES FOR SUSTAINABLE JOB CREATION IN WOOD-BASED MICRO AND SMALL-SCALE ENTERPRISES IN NIGERIA

Shuaibu Saminu[1], Hassan A.M.[2], Kareem W.B.[3] Mohammed B.M.[4]
Department of Technical Education, Faculty of Education,
Northwest University, Kano[1]
Department of Industrial and Technology Education,
Federal University of Technology, Minna[2,3,4]
Shuaibu772@gmail.com
08036933849

Abstract

This study investigated the project and resource management competencies required for sustainable job creation in wood-based Micro and Small-Scale Enterprises (MSEs) in Nigeria. A cross-sectional survey research design was employed to collect data from a representative sample of 229 respondents comprising woodwork lecturers, teachers, and enterprise owners across the North-West geopolitical zone of Nigeria. Data were collected using a researcher-developed questionnaire structured on a five-point rating scale, with 13 items focused on project management competencies and 14 items on resource management competencies. The instrument's validity was confirmed by experts in Technology and Vocational Education, while reliability tests conducted in Bauchi State yielded Cronbach's Alpha coefficients of 0.821 and 0.832, indicating high internal consistency. Data analysis involved the use of Mean statistics to answer the research questions and Analysis of Variance (ANOVA) to test the null hypotheses at a 0.05 level of significance. The findings revealed that essential project management competence skills for sustainable job creation include resource planning and utilization, personnel engagement, integration of process and technology, adherence to standards, and the application of relevant knowledge, skills, and foresight in project execution. Similarly, critical resource management competencies identified include effective scheduling and supply of materials, proper inventory control, strategic workforce deployment, planning for skill development, fostering interpersonal relationships, and aligning resource functions with enterprise growth objectives. The results also showed no significant difference in the mean responses of lecturers, teachers, and entrepreneurs regarding the required project and resource management competence skills. Based on these findings, the study recommended that technical and vocational training institutions collaborate with relevant government agencies to develop practical training programs that equip MSE operators with the competencies necessary for effective project and resource management. Strengthening these competencies is essential for improving enterprise sustainability, enhancing productivity, and creating sustainable job opportunities within Nigeria's wood-based MSE sector.

Keywords: Project Management, Resource Management, Competence Skills, Wood-Based Enterprises, MSEs, Sustainable Job Creation

Introduction

Micro and Small-Scale Enterprises (MSEs) have been widely acknowledged as critical drivers of economic growth, employment generation, and poverty alleviation in developing nations, with Nigeria being no exception. These enterprises promote the production of goods and services, create jobs, and contribute significantly to national income, thereby supporting the country's economic advancement (Holcombe, 2017). The World Bank classifies micro enterprises as those employing one to nine persons, while small enterprises are those with a workforce ranging from ten to forty-nine individuals (World Bank, 2022). Among these, wood-based MSEs have become a vital source of employment, providing opportunities for

self-reliance and economic empowerment, particularly for technical college graduates and other skilled individuals engaged in the production of wood products for domestic and commercial use (Bhavani, 2016; Adedokun *et al.,* 2005).

Despite their enormous potential, the contribution of wood-based MSEs to sustainable job creation in Nigeria remains largely underdeveloped. Available reports indicate that nearly 80% of small and medium enterprises in Nigeria collapse within the first five years of operation (SMEDAN, 2015). Scholars such as Olabiyi and Uzoka have pointed to factors such as weak management structures, poor planning, and ineffective resource utilisation as major contributors to this high failure rate. In particular, the absence of essential management competencies, especially in project and resource management, continues to undermine the sustainability and job creation capacity of wood-based enterprises across the country.

Project management has been described as a systematic process that involves planning, organising, and coordinating resources to achieve defined objectives efficiently (Laslo, 2010; Vidal & Marle, 2008). Within the wood-based enterprise sector, project management competencies are indispensable for coordinating personnel, materials, and technology to meet production deadlines and ensure customer satisfaction. As Smith and Jones (2022) highlighted, failure to develop these competencies often results in production delays, uncertainty, and resource wastage, all of which threaten enterprise performance and survival. Roy (2007) similarly emphasised that the fragility of project requirements and inadequate control mechanisms contribute significantly to the failure of small projects, particularly in technical sectors such as wood-based production.

Closely related to project management is resource management, which refers to the systematic planning, acquisition, allocation, and control of material, human, and financial resources required for enterprise operations (Anyadike, 2014). According to Armstrong, beyond simply identifying available resources, entrepreneurs must possess the skills to allocate and manage them effectively to enhance productivity and sustain operations. In wood-based enterprises, where access to quality raw materials, effective workforce mobilisation, and sound inventory management are central to production efficiency, resource management competencies are essential for ensuring enterprise sustainability (Smith & Jones, 2022).

Unfortunately, many wood-based MSEs in Nigeria operate without a structured management framework to guide project execution and resource utilisation. Moon and Desouza (2011) noted that the absence of formal management structures within small enterprises often leads to operational inefficiencies, while Mintzberg (2009) underscored the need for managers to understand how to coordinate action, people, and information effectively. Without these competencies, the ability of wood-based enterprises to survive, grow, and create sustainable jobs remains severely constrained. In response to these challenges, this study sought to identify the specific project and resource management competencies required for sustainable job creation within wood-based MSEs in Nigeria.

Statement of the Problem

Wood-based Micro and Small-Scale Enterprises (MSEs) are globally acknowledged as a major pillar for socio-economic development, wealth creation, and job opportunities in both developing and developed nations (MMSEs Survey, 2017). These enterprises play a significant role in employment generation, income redistribution, and poverty alleviation. Despite their immense economic contributions, the survival and growth of wood-based MSEs, particularly in Nigeria, remain a concern for policymakers, practitioners, and researchers alike. Globally, micro and small enterprises account for almost 90% of businesses (Gherghina *et al.,* 2020), while in Nigeria, over 41 million such enterprises employ nearly 60 million people, contributing about 50% to the nation's Gross Domestic Product (NBS, 2019).

However, available evidence reveals that most MSEs in Nigeria, especially those within the wood-based sector, fail to survive beyond the first five years of operation (MSEsDAN, 2015; Olatutu, 2021).

This alarming failure rate has been largely attributed to deficiencies in essential management competencies required for sustaining enterprise growth. Notably, poor project and resource management skills hinder the capacity of these enterprises to plan, organize, utilize resources effectively, and drive sustainable job creation. Without the requisite project management competencies, such as resource planning, personnel engagement, and integration of technology, alongside sound resource management practices, including effective material scheduling, workforce deployment, and skill development, these enterprises remain vulnerable to stagnation and collapse. This situation not only results in the continuous closure of wood-based MSEs but also contributes to high unemployment rates, reduced revenue generation, and loss of job opportunities in Nigeria. Therefore, it has become imperative to examine the project and resource management competencies necessary for sustainable job creation in wood-based MSEs in Nigeria.

Aim and Objectives of the Study

The aim of the study was to investigate the project and resource management competencies necessary for sustainable job creation in wood-based MSEs in Nigeria. Specifically, the objectives of the study were to determine the:

1. Project Management Competence for Sustainable Job Creation in Wood-Based MSEs in Nigeria
2. Resource Management Competence for Sustainable Job Creation in Wood-Based MSEs in Nigeria

Research Questions

The following research questions were raised and answered:

1. What are the project management competence skills required for sustainable job creation in wood-based MSEs in Nigeria?
2. What are the resource management competence skills required for sustainable job creation in wood-based MSEs in Nigeria?

Hypotheses

The following null hypotheses were formulated and tested at .05 level of significance:

H_{01}: There is no significant difference among the mean responses of lecturers, teachers, and entrepreneurs in the wood-based sector on the project management competence skills required for sustainable job creation in MSEs in Nigeria.

H_{02}: There is no significant difference among the mean responses of lecturers, teachers, and entrepreneurs in the wood-based sector on the resource management competence skills required for sustainable job creation in MSEs in Nigeria.

Methodology

The study adopted a cross-sectional survey research design to collect relevant data from a wide range of respondents at a single point in time. This design was considered appropriate because it enabled the researcher to elicit information from different categories of stakeholders involved in wood-based MSEs in Nigeria. The study was conducted in the North-West geopolitical zone of Nigeria. The population for the study consisted of 536 respondents, including 26 woodwork lecturers from Colleges of Education, 12 woodwork lecturers from Universities, 76 woodwork teachers from Technical Colleges, and 422 owners of wood-based MSEs within the study area. From this population, a representative sample of

229 respondents was determined using Yaro Yamane's statistical formula at a 0.05 level of precision.

Data collection was carried out using a researcher-developed questionnaire. The questionnaire consisted of two sections designed to collect data on project management competence skills and resource management competence skills. It was structured on a five-point rating scale of Strongly Agree (4), Agree (3), Disagree (2), Strongly Disagree (1), and No Opinion (0). The instrument contained 13 items for project management competence and 14 items for resource management competence. To ensure the validity of the instrument, three experts from the field of Technology and Vocational Education were consulted to review the items for relevance, clarity, and alignment with the research objectives. For reliability, a pilot test was conducted in Bauchi State, which falls outside the study area, involving 35 respondents consisting of subject matter experts, college lecturers, technical teachers, and wood-based enterprise owners. The reliability of the instrument was established using Cronbach's Alpha, which yielded coefficients of 0.821 and 0.832. These values indicated high internal consistency and suitability of the instrument for the main study.

Data collection was carried out by the researcher with the assistance of seven trained research assistants. The assistants were adequately trained on the study objectives, the administration of the questionnaire, and ethical considerations to ensure uniformity and accuracy in the data collection process. The administration and retrieval of the questionnaires were completed within one week. Data analysis was performed using the Statistical Package for Social Sciences (SPSS) version 27. The research questions were answered using Mean statistics, with the decision rule based on the real limits of numbers. Analysis of Variance (ANOVA) was employed to test the two null hypotheses at a 0.05 level of significance. A 2-tailed significance value greater than 0.05 indicated no significant difference in the mean responses among lecturers, teachers, and entrepreneurs, while a value less than 0.05 indicated a significant difference.

Research Question 1

What are the project management competence skills required for sustainable job creation in wood-based MSEs in Nigeria? The results for answering research question one are presented in Table 1.

Table 1: Mean and standard deviation of respondents' responses on the project management competence skills required for sustainable job creation in wood-based MSEs in Nigeria

S/N	Items	Mean	SD	Decision
1.	Ability to plan effective utilization of resources for successful project execution.	3.65	.93	Agreed
2.	Ability to organize and control project resources efficiently.	3.71	.89	Agreed
3.	Ability to engage personnel effectively for timely project accomplishment.	3.71	.88	Agreed
4.	Ability to coordinate effective interpersonal interactions within project teams.	3.61	.96	Agreed
5.	Ability to harmonize processes and technology in project execution.	3.62	.97	Agreed
6.	Ability to apply command strategies for efficient project delivery.	3.74	.87	Agreed
7.	Ability to follow and enforce project best practices.	3.76	.87	Agreed
8.	Ability to adhere to and ensure compliance with project	3.64	.95	Agreed

	standards.			
9.	Ability to implement project guidelines consistently.	3.58	1.02	Agreed
10.	Ability to apply relevant knowledge and skills in executing project tasks.	3.65	.93	Agreed
11.	Ability to provide supportive cultural environments for project success.	3.71	.89	Agreed
12.	Ability to adopt relevant project methodologies based on project type.	3.71	.88	Agreed
13.	Ability to apply foresight and insight in project system management.	3.62	.94	Agreed
	Grand Mean	**3.67**	**.93**	**Agreed**

Table 1 shows the mean and standard deviation values of respondents' responses on the project management competence skills required for sustainable job creation in wood-based MSEs in Nigeria, with mean values ranging between 3.58 and 3.76, and standard deviation values between 0.87 and 1.02, with a grand mean value of 3.67 and a standard deviation of 0.93. These values indicated that the respondents generally agreed that all the listed project management competence skills are required for sustainable job creation in wood-based MSEs in Nigeria.

Research Question 2

What are the resource management competence skills required for sustainable job creation in wood-based MSEs in Nigeria? The results for answering research question two are presented in Table 2.

Table 2: Mean and standard deviation of respondents' responses on the resource management competence skills required for sustainable job creation in wood-based MSEs in Nigeria

S/N	Items	Mean	SD	Decision
6.	Ability to schedule material purchases appropriately.	3.63	.95	Agreed
7.	Ability to ensure the timely supply of materials.	3.74	.87	Agreed
8.	Ability to implement effective material receiving processes.	3.76	.87	Agreed
9.	Ability to coordinate transportation of materials efficiently.	3.64	.93	Agreed
10.	Ability to manage inventory accurately within the enterprise.	3.58	1.00	Agreed
11.	Ability to identify and make materials available for production on time.	3.65	.93	Agreed
12.	Ability to utilize human resources judiciously.	3.71	.89	Agreed
13.	Ability to assign responsibilities based on human resource strengths.	3.71	.88	Agreed
14.	Ability to mobilize the workforce to meet production targets.	3.71	.88	Agreed
15.	Ability to plan strategically for acquiring current and future job-related skills.	3.76	.87	Agreed
16.	Ability to build positive interpersonal and social relationships within the enterprise.	3.63	.95	Agreed
17.	Ability to develop employees' dedication and capacity for competitive advantage.	3.61	.99	Agreed
18.	Ability to manage individual and organizational development effectively.	3.65	.93	Agreed

19.	Ability to perform strategic functions in enterprise resource planning.	3.71	.89	Agreed
	Grand Mean	**3.68**	**.92**	**Agreed**

Table 2 shows the mean and standard deviation values of respondents' responses on the resource management competence skills required for sustainable job creation in wood-based MSEs in Nigeria, with mean values ranging between 3.58 and 3.76, and standard deviation values between 0.87 and 1.00, with a grand mean value of 3.68 and a standard deviation of 0.92. These values indicated that the respondents generally agreed that all the identified resource management competence skills are essential for promoting sustainable job creation in wood-based MSEs in Nigeria

Hypothesis One

There is no significant difference among the mean responses of lecturers, teachers, and entrepreneurs in the wood-based sector on the project management competence skills required for sustainable job creation in MSEs in Nigeria. The results for testing hypothesis one are presented in Table 3.

Table 3: Analysis of Variance for the test of significant difference among the mean responses of lecturers, teachers, and entrepreneurs in the wood-based sector on the project management competence skills required for sustainable job creation in MSEs in Nigeria

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.453	2	1.726	2.005	.137*
Within Groups	194.599	226	.861		
Total	198.052	228			

Table 3 shows the Analysis of Variance (ANOVA) results for the test of significant difference among the mean responses of lecturers, teachers, and entrepreneurs on the project management competence skills required for sustainable job creation in wood-based MSEs in Nigeria, with an F-value of 2.005 and a significance value of 0.137. These values indicated that there is no significant difference among the mean responses of the groups on the required project management competence skills.

Hypothesis Two

There is no significant difference among the mean responses of lecturers, teachers, and entrepreneurs in the wood-based sector on the resource management competence skills required for sustainable job creation in MSEs in Nigeria. The results for testing hypothesis two are presented in Table 4.

Table 4: Analysis of Variance for the test of significant difference among the mean responses of lecturers, teachers, and entrepreneurs in the wood-based sector on the resource management competence skills required for sustainable job creation in MSEs in Nigeria

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.014	2	1.007	1.286	.278*
Within Groups	176.964	226	.783		
Total	178.978	228			

Table 4 shows the Analysis of Variance (ANOVA) results for the test of significant difference among the mean responses of lecturers, teachers, and entrepreneurs on the resource management competence skills required for sustainable job creation in wood-based MSEs in Nigeria, with an F-value of 1.286 and a significance value of 0.278. These values indicated that there is no significant difference among the mean responses of the groups on the required resource management competence skills.

Findings

1. Key project management competence skills required for sustainable job creation in MSEs in Nigeria include resource planning and utilization, personnel engagement, integration of process and technology, adherence to standards, and the application of relevant knowledge, skills, and foresight in executing projects effectively.
2. There was no significant difference among the mean responses of lecturers, teachers, and entrepreneurs in the wood-based sector on the project management competence skills required for sustainable job creation in MSEs in Nigeria.
3. Key resource management competence skills required for sustainable job creation in MSEs in Nigeria include effective scheduling and supply of materials, proper inventory control, strategic workforce deployment, planning for skill development, fostering interpersonal relationships, and aligning resource functions with enterprise growth objectives.
4. There was no significant difference among the mean responses of lecturers, teachers, and entrepreneurs in the wood-based sector on the resource management competence skills required for sustainable job creation in MSEs in Nigeria.

Discussion of Findings

Findings on the project management competence skills required for sustainable job creation in MSEs in Nigeria revealed that resource planning and utilization, personnel engagement, integration of process and technology, adherence to standards, and the application of relevant knowledge, skills, and foresight in executing projects effectively are the core capabilities needed. This insight highlights the complex and integrative nature of project management in wood-based MSEs, where aligning human resources, material inputs, and operational procedures is crucial for achieving job creation and sustainability. This result reveals the operational realities of small-scale enterprise leadership, where the competence to design and execute structured projects can determine long-term viability. It supports Banjo *et al*. (2017), who noted that enterprises equipped with strong planning and execution capabilities were better positioned to foster employment growth and operational success. Adedokun *et al*. (2005) similarly emphasized that in the Akure wood-processing sector, project coordination and effective resource use significantly contributed to economic development. Manish (2016) further adds that institutionalizing project and quality management practices helps smaller firms achieve measurable performance gains. Unlike the findings of Ekhuemelo *et al*. (2017), which highlighted weak management practices in Gboko's wood enterprises due to informality and poor exposure to modern tools, this present study reflects increasing formalization and competence among MSEs. A plausible explanation for this positive development is the rise in vocational training programs, government-led enterprise support schemes, and growing market demand for quality-driven service delivery. The implication here is that promoting project management skills in wood-based MSEs could act as a catalyst for increasing their productivity and enhancing their role as engines of sustainable employment. Thus, enterprise development policies and educational interventions should prioritize the integration of these competencies within capacity-building frameworks.

In addition, the test of significant difference among the mean responses of lecturers, teachers, and entrepreneurs in the wood-based sector on the project management competence skills required for sustainable job creation in MSEs in Nigeria revealed that there was no statistically significant difference. This finding indicates a shared understanding among these stakeholders regarding the essential managerial skills needed for effective project delivery in the wood sector. This convergence supports the conclusions of Nwite (2019), who noted that entrepreneurial education in Nigerian tertiary institutions increasingly mirrors industry needs and expectations. It also resonates with Oluwabusolami (2021), who found that collaboration between educational and business stakeholders enhances innovation and adaptation in small enterprises. Aiyeloja *et al*. (2022) also confirmed that such alignment in the wood-based sector fosters consistent standards and improved productivity. By contrast, Mohammed *et al*. (2021) reported disconnections between theoretical instruction and practical application in MSEs management, which this study appears to counter, suggesting that stakeholder perspectives are becoming increasingly harmonized. The implication of this alignment is noteworthy; it not only validates the proposed project management competencies but also signals readiness for their institutionalization in formal education and enterprise development programs. It reinforces the importance of stakeholder collaboration in curriculum design and in shaping policy that reflects practical business realities. Ultimately, this agreement lays the groundwork for scaling up management training that is both contextually relevant and widely endorsed within Nigeria's wood-based MSE ecosystem.

Findings on the resource management competence skills required for sustainable job creation in MSEs in Nigeria revealed that effective scheduling and supply of materials, proper inventory control, strategic deployment of human resources, continuous planning for workforce skill development, and fostering of positive interpersonal relationships are critical components. This finding highlights that sustainable job creation in the wood-based sector depends not only on operational efficiency but also on the ability of MSEs to anticipate workforce needs and maintain harmonious internal dynamics. This outcome supports the findings of Adedokun *et al*. (2005), who reported that the performance of wood-based enterprises in Ondo State was strongly influenced by their ability to plan resource use effectively. Similarly, Ekhuemelo *et al*. (2017) found that resource management practices, especially inventory control and workforce engagement, significantly contributed to the viability of wood-based businesses in Gboko, Benue State. Moreover, the emphasis on human resource optimization and skills development is consistent with Nwite (2019), who emphasized the importance of entrepreneurial education in equipping individuals with the competencies needed to manage resources and create employment opportunities post-graduation. Unlike earlier studies such as James (2015), which emphasized the financial impact of small-scale enterprises without detailing internal operational practices, this study brings to the fore the interdependence of material flow, labor efficiency, and enterprise growth. A possible reason for this difference is the evolving operational landscape of MSEs, where material scarcity, high labor costs, and skill gaps necessitate a more comprehensive resource strategy. Olatutu (2021) similarly pointed out that survival strategies among Nigerian micro-enterprises increasingly depend on internal capacity to manage both human and physical assets effectively. The implication of this finding is that any management competence framework targeting MSEs in the wood sector should integrate practical strategies for inventory control, material logistics, and staff development. It suggests that training programs should not be limited to technical skills but must also include modules on interpersonal management and strategic resource alignment to boost enterprise sustainability and job creation potential.

In addition, the test of significant difference among the mean responses of lecturers, teachers, and entrepreneurs in the wood-based sector on the resource management competence skills required for sustainable job creation in MSEs in Nigeria revealed no statistically significant variation. This indicates a unified perception among the various respondent categories on the relevance and importance of resource management skills in the context of sustainable enterprise operation. This finding aligns with that of Alu Chituru *et al*. (2022), who reported broad stakeholder agreement on budgeting and operational practices necessary for MSEs sustainability. It also resonates with Mohammed *et al*. (2021), who found that resource-related challenges are universally acknowledged as critical barriers to MSEs performance across sectors. The convergence of perspectives implies that the identified competencies are not only theoretically sound but also practically endorsed by those involved in both the educational and business aspects of wood-based enterprise development. In summary, the shared understanding of resource scheduling, inventory accuracy, workforce mobilization, and developmental planning as key drivers of sustainability confirms their essential role in the proposed management competence framework. This uniformity in perception among stakeholders enhances the credibility of the framework and supports its application in capacity-building efforts aimed at improving employment outcomes and operational resilience among wood-based MSEs in Nigeria.

Conclusion

This study has provided empirical insights into the project and resource management competencies required for sustainable job creation within wood-based MSEs in Nigeria. The findings revealed that project management competence skills such as effective resource planning and utilization, personnel engagement, integration of processes and technology, strict adherence to standards, and the application of relevant knowledge and foresight are essential for ensuring the sustainability and growth of these enterprises. Similarly, resource management competence skills, including timely scheduling and supply of materials, proper inventory control, strategic workforce deployment, continuous skill development, and alignment of resources with enterprise objectives, are crucial for achieving sustainable operations. The study also established that there was no significant difference among the mean responses of lecturers, teachers, and entrepreneurs on these required competencies, suggesting a consensus among key stakeholders regarding the management skills needed to drive sustainable job creation in the sector. These findings underscore the need to strengthen capacity-building efforts and integrate these competencies into vocational training and enterprise development initiatives to enhance the performance and sustainability of wood-based MSEs in Nigeria.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. Technical and vocational training institutions, in collaboration with the Ministry of Labour and Employment, should train enterprise owners and prospective entrepreneurs in resource planning and utilization, personnel engagement, integration of process and technology, adherence to standards, and applying knowledge, skills, and foresight through hands-on project management modules.
2. The Industrial Training Fund (ITF), local government enterprise support departments, and cooperative unions should organize enterprise clinics and training sessions focused on effective scheduling and supply of materials, inventory control, strategic workforce deployment, skill development, interpersonal relationship building, and aligning resource functions with enterprise growth objectives.

References

Adedokun, M. O., Oyun, A. B., Aina, O. M., & Adetogun, A. C. (2005, October 18–20). Small-scale, wood-based processing enterprises: their characteristics and impact on people of Akure local government area of Ondo State. *Paper presented at the Farm Management Association of Nigeria Conference*, Asaba, Nigeria.

Aiyeloja, A. A., Adedeji, G. A., & Chilaka, V. U. (2022). Economic and environmental evaluation of wood-based enterprises at a clustered sawmill in Port Harcourt, Nigeria. *Journal of Forest Science and Environment, 12*(7), 36–48.

Anyadike, N. O. (2014). Effective strategies for the improvement of human and material resources management in the Nigerian local government system. *International Review of Management and Business Research, 3*(2), 1264–1274.

Armstrong, M. (2009). *Armstrong's handbook of human resources management practice (11th ed.).* India: Replika Press PVT. LTD.

Banjo, J. O. S., Falola, O. A., & Ganiyu, Y. K. (2017). Effects of managerial skills required in entrepreneurship among undergraduates in Oyo State, Nigeria. *Makerere Journal of Higher Education, 3*(1), 97–101.

Bhavani, T. A. (2016). *Globalization and India's small-scale industries, technology competitiveness*. New Delhi, India.

Ekhuemelo, D. O., Torvenda, A. R., & Tembe, E. T. (2017). Analysis of wood-based enterprise in Gboko Local Government Area of Benue State, Nigeria. *Asian Research Journal of Agriculture, 4*(1), 1–10.

Gherghina, S. C., Botezatu, M. A., Hosszu, A., & Simionescu, L. N. (2020). Small and medium-sized enterprises (SMEs): The engine of economic growth through investments and innovation. *Sustainability, 12*(1), 347. https://doi.org/10.3390/su12010347

Holcombe, R. G. (2017). *Public policy and the quality of life: Market incentives versus government planning.* Westport, Conn.: Greenwood Press.

James, N. (2015). The role of small-scale enterprises in the achievement of economic growth in Lagos, Nigeria. *International Journal of Social Sciences and Humanities, 3*(1). ISSN: 2141–1162.

Laslo, Z. (2010). Project portfolio management: An integrated method for resource planning and scheduling to minimise planning/scheduling-dependent expenses. *International Journal of Project Management, 28*(6), 609–618.

Manish, A. S. (2016). A quality management system implementation framework for small-sized companies *(Master's thesis*). North Dakota State University.

Mintzberg, H., Quinn, J. B., & Ghoshal, S. (2009). *The strategy process*. London: Prentice Hall.

Mohammed, S. A., Balarabe, A. J., & Salwa, K. (2021). Challenges affecting the performance of small and medium-scale enterprises (SMEs) in Nigeria. *Journal of Technology Management and Technopreneurship, 3*(1), 51–73.

Moon, D. T., & Desouza, E. J. (2011). *Factors affecting the performance of small and medium-sized enterprises in Europe*.

Murphy, A., & Ledwith, A. (2007). Project management tools and techniques in high-technology SMEs. *Management Research News, 30*(2), 153–166.

National Bureau of Statistics. (2019). National survey of micro small & medium enterprises (MSMEs). *http://www.nigerianstat.gov.ng/*

National Survey of Micro, Small, and Medium Enterprises. (2017). *Publication of the third edition of the national survey of MSMEs*.

Nwite, O. (2019). Entrepreneurship education in Nigerian tertiary institutions: A remedy to graduates' unemployment. *British Journal of Education, 4*(5), 16–28.

Olabiyi, O. S., & Uzoka, N. (2022). Pre-retirement vocational entrepreneurship skills development needs of university administrative employees in Southwest Nigeria. *Nigerian Online Journal of Educational Sciences and Technology (NOJEST), 4*(1), 69–80.

Olatutu, O. S. (2021). Survival strategies of microenterprises in Nigeria (*Doctoral dissertation*). Walden University.

Oluwabusolami, A. (2021). Development of a change management framework to enhance business model innovation, which improves organizational performance in the Nigerian travel sector (*Doctoral dissertation*). University of Wales Trinity Saint David.

Roy, P. (2007). Self-management and the future of software design. In Proceedings of the 3rd International Workshop on Formal Aspects of Component Software (FACS 2006). *Electronic Notes in Theoretical Computer Science, 182*, 201–217.

Small and Medium Enterprises Development Agency of Nigeria (SMEDAN). (2015). *Small business by the numbers. April 2003. SBA, Small Business Economic Indicators for 20017, June 2023.*

Smith, J. M., & Jones, J. R. (2022). *The impact of woodwork technology management skills on the performance of woodworking businesses*. Retrieved from http://repository.unn.edu.ng/handle/123456789/1731

Vidal, L., & Marle, F. (2008). Understanding project complexity: Implications on project management. *Kybernetes, 37*(8), 1094–1110.

World Bank. (2022). *Assessment of progress made by AU Member Countries in implementing the Abuja Call for accelerated action to enable universal access to health care services in Africa.* African Union, United States: World Bank.

SUB-THEME 4

CONSTRUCTION TECHNOLOGY

Developing a Digital Training Framework for Technical Vocational Education and Training (TVET) in Nigeria: Leveraging Construction Technologies for Sustainable Workforce Development

Onatere-Ubrurhe, Joyce Ogheneruona[1]
Department of Technology Education, Alvan Ikoku Federal University of Education, Owerri, Nigeria.
joyce.onatere-ubrurhe@alvanikoku.edu.ng

Ugworji, Chrisjoy Tobechukwu[2]
Department of Technology Education, Alvan Ikoku Federal University of Education, Owerri, Nigeria.
tobechukwu.ugwuorji@alvanikoku.edu.ng

Uchegbu, Chima Chidiebere[3]
Department of Technology Education, Alvan Ikoku Federal University of Education, Owerri, Nigeria.
chima.uchegbu@alvanikoku.edu.ng

Abstract
Technical Vocational Education and Training (TVET) is crucial for equipping individuals with practical skills necessary for national development. In Nigeria, the construction industry demands increasingly digital skills; however, TVET institutions often lag in integrating emerging construction technologies like Building Information Modeling (BIM), Virtual Reality (VR), and Project Management tools. This research aimed to develop a digital training framework that aligns TVET curricula with the evolving needs of the construction sector to foster sustainable workforce development. Using a purposive sampling method, data were collected from 287 respondents comprising TVET Educators, Students, and Construction industry professionals. Descriptive statistics were employed for analysis. Findings revealed that digital construction technologies are moderately to minimally integrated into TVET curricula, with Basic CAD tools being the most available while advanced technologies remain scarce. Major challenges include high costs of digital tools, inadequate infrastructure, lack of trained instructors, and insufficient government support. Furthermore, a significant skills gap exists, as 69% of industry professionals believe TVET graduates lack essential digital skills. Despite these challenges, there was overwhelming support for a structured digital training framework. Based on the findings, a phased, industry-aligned digital training framework was proposed, focusing on curriculum integration, instructor capacity building, infrastructure enhancement, industry partnerships, and continuous curriculum updates. This study concludes that digital transformation in TVET is vital for enhancing graduate employability and achieving sustainable workforce development in Nigeria's construction sector. Future research should explore the long-term impacts of digital training on employability and productivity across Nigeria's diverse regions.
Keywords: TVET, digital construction technologies, workforce development, curriculum integration, employability.

Introduction
Technical Vocational Education and Training (TVET) plays a critical role in equipping individuals with practical skills and knowledge essential for national development and economic growth (Akindele & Olabimtan 2023). In Nigeria, the construction industry stands as a vital sector, contributing significantly to employment and infrastructure development.

However, there remains a noticeable gap between the skills TVET graduates possess and the evolving demands of the construction industry, especially in the area of digital construction technologies (Nagar, 2024).

The integration of digital tools such as Building Information Modeling (BIM), and project management software has become increasingly important for enhancing efficiency and productivity in construction projects (Zong & Juwaheer, 2024). Studies have shown that countries with well-structured TVET systems integrated with digital skills tend to produce more competitive and adaptable workforces (Rajamanickam *et al.,* 2024) Therefore, developing a digital training framework for TVET in Nigeria is crucial to align educational outcomes with industry needs and drive sustainable workforce development (UNESCO, 2023; Vararean-Cochisa, & Crisan, 2025).

Despite the importance of TVET in national development, the current training models in Nigeria often lack the necessary digital components needed to meet industry standards. Construction technologies are advancing rapidly, yet many TVET institutions still rely on outdated curricula that fail to equip students with essential digital skills. This gap has led to a mismatch between graduates' competencies and industry expectations, affecting productivity and innovation in the construction sector (Akindele & Olabimtan 2023). Hence, there is a pressing need for a structured digital training framework that integrates modern construction tools into TVET curricula to bridge this gap and foster a sustainable, digitally competent workforce. The aim of this research is to develop a digital training framework for TVET, leveraging construction technologies for sustainable workforce development in Nigeria.

Literature review

Concept of Technical Vocational Education and Training (TVET)

Technical Vocational Education and Training (TVET) is recognized as a crucial educational pathway that equips individuals with practical and occupational skills for workforce development. TVET programs emphasize hands-on training and technical knowledge, making them essential for economic development and industrial growth. In developing countries like Nigeria, TVET plays a vital role in addressing unemployment and skill shortages, providing students with the skills required for the labor market. However, the traditional training models used in Nigerian TVET institutions often lag behind industry requirements, highlighting the need for modernized training approaches (Ajeniweni *et al.,* 2024).

The evolving construction sector requires professionals skilled in both conventional practices and emerging digital technologies, which TVET institutions must address through updated curricula and innovative teaching methodologies. Strengthening TVET through the integration of digital construction technologies is, therefore, critical for producing a workforce that meets contemporary industry demands (Rajamanickam *et al.,* 2024; UNESCO, 2023).

Overview of Digital Construction Technologies

Digital construction technologies have revolutionized the construction industry by enhancing efficiency, accuracy, and collaboration. These technologies include Building Information Modeling (BIM), Virtual Reality (VR) and Augmented Reality (AR), Project Management tools and Digital site monitoring tools. The adoption of these tools facilitates better project visualization, real-time data sharing, and improved decision-making processes (Vararean-Cochisa, & Crisan, 2025).

The construction industry’s shift towards digitalization has increased the demand for skilled professionals who can operate these technologies, making their integration into TVET programs essential. Moreover, studies have shown that students trained with digital

construction tools demonstrate higher proficiency in project planning, execution, and management (Onatere-Ubrurhe *et al.,* 2025).

Building Information Modeling (BIM)

Building Information Modeling (BIM) is a digital representation of the physical and functional characteristics of a facility, providing a shared knowledge resource for information management throughout a building's lifecycle. BIM enhances collaboration among construction stakeholders, reducing errors and project costs (Wang, *et al.,* 2022).

Integrating BIM into TVET curricula has proven to improve students' understanding of construction processes, enabling them to produce detailed and accurate project models. The adoption of BIM also equips students with critical digital skills needed in modern construction practices, examples of BIM software are Revit and ArchiCAD used for designing, modeling, and managing building projects. (Hoai Le *et al.,* 2022).

Virtual Reality (VR) and Augmented Reality (AR)

Virtual Reality (VR) and Augmented Reality (AR) are immersive technologies that offer interactive and visual learning experiences. VR creates a simulated environment where students can practice construction techniques without real-world risks, while AR overlays digital information onto physical environments. An example of VR too is Enscape, used in Real-time VR rendering for architecture and construction while an example of AR tool is Microsoft Hololens used in construction for on-site visualization of models, enabling users to see how designs fit within existing spaces and facilitating better decision-making during the building process. (Fowler, 2015; Alburub *et al.,* 2011).

These technologies have the capacity to enhance spatial awareness, safety training, and technical skill development in TVET programs. By incorporating VR and AR, TVET institutions can provide students with practical, hands-on experience, bridging the gap between theoretical knowledge and real-world application (Onatere-Ubrurhe *et al.,* 2025).

Project management tools

Project management tools are essential for planning, organizing, tracking, and managing construction projects efficiently. They help in scheduling, budgeting, resource allocation, risk management, and collaboration among teams. The following are examples of project management tools commonly used in the construction industry. An example of a project management software is Primavera P6, a construction scheduling and project control tool used for large-scale projects. It helps manage complex schedules, resources, and risks (Kerzner, 2022).

Digital Site Monitoring Tools

Digital site monitoring tools offer real-time data collection and site analysis capabilities, enhancing construction project oversight and quality control. Digital site monitoring tools also improve safety training by identifying potential hazards and promoting proactive risk management practices. An example of digital monitoring tools are Drones, they provide aerial views of construction sites, facilitating accurate surveying and progress monitoring. Incorporating these technologies into TVET programs equips students with modern site management skills, preparing them for industry demands (Mendes *et al.,* 2022).

The Role of Digital Technologies in Workforce Development

Digital technologies play a pivotal role in workforce development by providing practical training opportunities and enhancing skill acquisition (Kraus *et al.,* 2023). These technologies improve efficiency, safety, and quality in construction projects, making digitally skilled workers highly valuable. TVET programs adopting digital tools report higher graduate employability and job readiness, demonstrating the importance of digital literacy in workforce development. Moreover, digital technologies foster innovation and adaptability, key attributes for sustainable economic growth (Onatere-Ubrurhe *et al.,* 2025).

Industry Demands for Digital Skill in Construction

The construction industry is evolving rapidly, requiring professionals to possess digital skills such as proficiency in BIM and other digital construction technologies. Employers now prioritize candidates with digital skills, as these competencies improve project execution and reduce construction errors (Jain, 2024). Studies show that companies that adopt digital technologies experience significant improvements in project delivery times and cost management. However, the Nigerian TVET system has yet to fully align its curriculum with these industry demands, creating a skills gap that affects graduates' employability (UNESCO 2023; Damek *et al.*, 2022).

The Need for Digital Construction Technologies in TVET Training

The integration of digital construction technologies in TVET is essential for producing a competent and adaptable workforce. These tools bridge the gap between theoretical education and practical application, enhancing students' technical proficiency and industry readiness. Moreover, digital technologies foster innovation and efficiency in construction projects (Davis, 2025), making their adoption critical for sustainable development. TVET institutions must prioritize digital integration to remain relevant and effective in skill development (UNESCO, 2023; Hoai Le *et al.*, 2022).

Integration of Digital Tools in TVET Curricula

Integrating digital tools into Technical Vocational Education and Training (TVET) curricula enhances students' employability by aligning their skills with industry needs. Effective integration necessitates curriculum redesign, investments in infrastructure, and faculty training to ensure educators are well-equipped to teach digital competencies (Zhong & Juwaheer, 2024).

Case studies from countries like Germany and Singapore demonstrate the success of digital integration in vocational education. In Singapore, the SkillsFuture initiative utilizes artificial intelligence to offer personalized learning recommendations, dynamically aligning training programs with the evolving needs of the economy and ensuring a competitive, adaptable workforce (Morley, 2025).

In Nigeria, efforts to integrate digital tools remain inconsistent. Studies have revealed that digital technologies are scarcely available and underutilized for TVET interactive learning in universities (Kennedy, *et al.*, 2022). Challenges include limited access to reliable internet connectivity, inadequate technological infrastructure, insufficient educator training, poor funding, and the absence of clear regulatory frameworks specific to digital integration in TVET. These issues necessitate a structured framework to guide implementation, ensuring that digital competence development in TVET involves a whole-institution approach engaging leaders, teachers, and learners (Zhong & Juwaheer, 2024).

Research Methodology

Population and sample

The target population for this study comprises TVET Educators, Students, and Construction industry professionals in Nigeria. These groups were selected because they are directly involved in the teaching, learning, and application of digital construction technologies. The purposive sampling technique was used to select participants and the total number of respondents is 287 (Etikan *et al.,* 2016). Table 1 contains the Respondents profile.

DEMOGRAPHICS	
Role	**Frequency**
Educator	86 (30%)
Student	117 (40.8%)
Construction Industry Professional	84 (29.3%)
Total Number of Respondents = 287	

Table 1. Respondents profile

Data Collection Methods

Data collection involved both primary and secondary sources to ensure a robust analysis.

Primary Data

Primary data was collected through survey method. A structured questionnaire was distributed to TVET Educators, Students, and Construction industry professionals to capture their perspectives on digital technology integration, challenges, and impacts on skill acquisition. The questionnaire was distributed online. The study targeted 300 respondents. However, 287 valid responses were obtained, representing a 95.7% response rate, which is considered highly acceptable for statistical analysis.

Secondary Data

Secondary data was sourced from academic journals, institutional reports, and industry publications to provide a contextual background and support the primary data findings.

Ethical Consideration

This study adhered to ethical research principles to ensure the protection and rights of participants. Informed consent was obtained by briefing participants on the study's purpose and ensuring their voluntary agreement to participate. Confidentiality was maintained by keeping all responses private and preventing the disclosure of any identifying information.

Data Analysis methods

The study employed descriptive statistical method (frequencies, percentages, mean, and standard deviation) to analyze the data, IBM SPSS Statistics 26 was used for data processing, ensuring the accuracy and reliability of the statistical outputs (IBM Corp., 2019).

Data Presentation and Interpretation

The analyzed data have been presented in table 2 followed by the interpretation.

Table 2. Results

NO.	QUESTIONS	RESPONSES						
1	To what extent are digital construction technologies integrated into the TVET curriculum at your institution? This question is for Educators and Students only.	Fully Integrated (5)	Well Integrated (4)	Moderately Integrated (3)	Minimally Integrated (2)	Not Integrated at all (1)	Mean	Standard Deviation
		25 (12.3)	29 (14.3)	62 (30.5)	59 (29.1)	28 (13%)	2.82	1.21
2	How frequently are digital construction technologies utilized in TVET at your institution? This question is for Educators and students only.	Very Frequently (5)	Frequently (4)	Occasionally (3)	Rarely (2)	Never (1)	Mean	Standard Deviation
		25 (12.3%)	30 (14.8%)	61 (30%)	59 (29.1%)	28 (13.8%)	2.83	1.21

3	Which of the following digital construction tools are available in your institution? (Select all that apply) This question is for Educators and students only. (a) Building Information Modeling (BIM), (b) Virtual Reality (VR) and Augmented Reality (AR), (c) Project Management tools, (d) Digital Site monitoring tools, (e) Basic Computer Aided Design (CAD) tools, (f) None	

Available Digital Construction Tools	Responses N	Percent	Percent of Cases
Building Information Modeling (BIM)	109	27.5%	53.7%
Virtual Reality (VR) and Augmented Reality (AR)	40	10.1%	19.7%
Project Management tools	52	13.1%	25.6%
Basic Computer Aided Design (CAD) tools	168	42.3%	82.8%
None	28	7.1%	13.8%
Total	397	100.0%	195.6%

a. Dichotomy group tabulated at value 1.

Continued

Table 2. Continued

NO.	QUESTION	RESPONSES						
4	How effective do you consider the current digital training provided in TVET curricula? This question is for Educators and students only.	Very effective (5)	Effective (4)	Neutral (3)	Ineffective (2)	Very Ineffective (1)	Mean	Standard Deviation
		26 (12.8%)	30 (14.8%)	60 (29.6%)	59 (29.1%)	28 (13.8%)	2.84	1.22

5	What are the major challenges facing the integration of digital tools into TVET curricula? (Select all that apply) This question is for Educators and students only. **(**a) Inadequate digital infrastructure, (b) High cost of digital tools, (c) Lack of trained instructors, (d) Resistance to technological change	

Challenges facing the integration of digital tools into TVET curricula	Responses N	Percent	Percent of Cases
Inadequate digital infrastructure	147	30.4%	72.4%
High cost of digital tools	161	33.3%	79.3%
Lack of trained instructors	113	23.3%	55.7%
Resistance to technological change	63	13.0%	31.0%
Total	484	100.0%	238.4%

a. Dichotomy group tabulated at value 1.

6	To what extent has the government supported the integration of digital technologies into TVET in Nigeria? This question is for Educators and students only.	Very supportive (5)	Supportive (4)	Neutral (3)	Unsupportive (2)	Very unsupportive (1)	Mean	Standard Deviation
		25 (12.3%)	30 (14.8%)	61 (30%)	60 (29.6%)	27 (13.3%)	2.83	1.20
		Continued						

Table 2. Continued

NO.	QUESTION	RESPONSES
7	Which of the following digital skills are most in demand in the construction industry? (Select all that apply) This question is for industry professionals only. (a) Digital Design and Modeling (e.g. BIM), (b) Use of Project Management tools, (c) Virtual and Augmented reality applications, (d) Data analysis for construction planning, (e) Drone operation for site monitoring, (f) Basic Computer Aided Design (CAD) tools	

Most in Demand Digital Skills in the Construction industry	Responses N	Percent	Percent of Cases
Digital Design and Modeling (e.g. BIM)	60	20.7%	71.4%
Use of Project Management tools	60	20.7%	71.4%
Virtual and Augmented reality applications	31	10.7%	36.9%
Data analysis for construction planning	61	21.0%	72.6%
Drone operation for site monitoring	33	11.4%	39.3%
Basic Computer Aided Design (CAD) tools	45	15.5%	53.6%
Total	290	100.0%	345.2%

a. Dichotomy group tabulated at value 1.

8	Do you think TVET	Yes	No

	graduates possess the necessary digital skills required in the construction industry? This question is for industry professionals only.	26 (31%)	58 (69%)
		Continued	

Table 2. Continued

NO.	QUESTION	RESPONSES
9	What strategies do you think would enhance digital training in TVET curricula? (Select all that apply) This question is for Educators and students and industry professionals. (a) Increased funding for digital tools and infrastructure, (b) Capacity building for instructors, (c) Establishing industry partnerships, (d) Regular curriculum updates	**TVET Digital training enhancement Strategies** / Responses N / Percent / Percent of Cases Increased funding for digital tools and infrastructure: 246 / 31.4% / 85.7% Capacity building for instructors: 252 / 32.1% / 87.8% Establishing industry partnerships: 140 / 17.9% / 48.8% Regular curriculum updates: 146 / 18.6% / 50.9% Total: 784 / 100.0% / 273.2% a. Dichotomy group tabulated at value 1.

10	How important are digital skills for enhancing employability in the construction industry? This Question is for Educators, Students and Industry Professionals.	Extremely important (5)	Important (4)	Moderately important (3)	Slightly important (2)	Not important (1)	Mean	Standard Deviation
		153 (53.3%)	115 (40.1%)	19 (6.6%)	0 (0%)	0 (0%)	4.47	0.62
11	Would you support a structured digital training framework for TVET in Nigeria? This Question is for Educators, Students and Industry Professionals.	Strongly support (5)	Support (4)	Neutral (3)	Do not support (2)	Strongly oppose (1)	Mean	Standard Deviation
		203 (70.7%)	84 (29.3%)	0 (0%)	0 (0%)	0 (0%)	4.71	0.46

Interpretation of Results

The data presented in Number 1 of table 2 reflects responses from educators and students regarding the integration of digital construction technologies into the TVET curriculum in Nigeria. The highest percentage of respondents (30.5%) indicated that such technologies are only moderately integrated, closely followed by 29.1% who reported minimal integration. A smaller proportion perceived the integration as well (14.3%) or fully (12.3%) implemented, while 13% felt there was no integration at all. The calculated mean score of 2.82, which falls

between "Moderately Integrated" (3) and "Minimally Integrated" (2), suggests that, on average, the integration of digital construction technologies remains below optimal levels. Additionally, the standard deviation of 1.21 indicates a moderate spread in opinions, highlighting varied experiences across institutions. Overall, the findings point to a need for significant improvement in the adoption of digital construction technologies in TVET programs to better support sustainable workforce development in Nigeria.

The data presented in Number 2 of table 2 reveals that the use of digital construction technologies in Technical Vocational Education and Training (TVET) institutions in Nigeria is generally moderate but not widespread. Only a small proportion of respondents—12.3% and 14.8%—indicated that such technologies are used very frequently and frequently, respectively. A larger share, 30%, reported occasional use, while 29.1% noted they are rarely used, and 13.8% said they are never used. The mean score of 2.83 on a 5-point scale suggests that, on average, digital construction technologies are used occasionally to rarely. The standard deviation of 1.21 indicates a relatively wide variation in responses, implying inconsistent adoption or access to digital technologies across institutions. This highlights the need for a more structured and inclusive digital training framework to enhance the integration of construction technologies in TVET for sustainable workforce development.

Number 3 of table 2 presents responses from educators and students on the availability of digital construction tools in their institutions as part of a study on developing a digital training framework for TVET in Nigeria. Among the tools listed, Basic Computer Aided Design (CAD) tools are the most commonly available, reported by 82.8% of respondents, highlighting their foundational role in current TVET curricula. Building Information Modeling (BIM) follows with 53.7%, suggesting moderate integration of more advanced technologies. Project Management tools (25.6%) and Virtual/Augmented Reality tools (19.7%) are less widely available, indicating limited exposure to immersive and managerial digital tools. Notably, 13.8% of respondents indicated that none of the listed tools were available at their institutions, revealing gaps in digital tools and infrastructure. Digital Site Monitoring Tools did not appear on the analysis table because none of the respondents selected it, suggesting either a lack of awareness or complete unavailability of such tools in the surveyed institutions. The total percentage exceeding 100% (195.6%) reflects that multiple responses were allowed per participant, underscoring the varied digital resources accessible across institutions.

The interpretation of number 4 of table 2 reveals a generally lukewarm perception of the effectiveness of current digital training in TVET curricula among educators and students in Nigeria. Out of the total respondents, only 12.8% rated the training as very effective and 14.8% as effective, indicating that less than a third (27.6%) view the training positively. In contrast, a larger proportion (42.9%) rated it as either ineffective (29.1%) or very ineffective (13.8%), while a significant 29.6% remained neutral. The mean score of 2.84, which falls just below the neutral midpoint of 3 on a 5-point Likert scale, further suggests a generally unsatisfactory view of the current digital training provisions. Additionally, the standard deviation of 1.22 indicates a moderate spread of opinions, reflecting varied experiences among the respondents. Overall, these results highlight the need for a more robust and effective digital training framework to better support TVET goals in Nigeria.

Number 5 of table 2 presents the responses of educators and students on the major challenges facing the integration of digital tools into Technical Vocational Education and Training (TVET) curricula in Nigeria. Among the four identified challenges, the high cost of digital tools was the most cited, with 161 responses, representing 33.3% of total responses and 79.3% of respondents, indicating that affordability is a major barrier. This is closely followed by inadequate digital infrastructure, cited by 147 respondents (30.4% of total responses, 72.4% of participants), highlighting a significant gap in technological support

systems. Lack of trained instructors was also notable, with 113 mentions (23.3%, 55.7% of cases), suggesting a deficiency in human capacity to deliver digital-based training. The least reported challenge was resistance to technological change, selected by only 63 respondents (13.0%, 31.0% of cases), showing that while some hesitation exists, it is less of a concern compared to structural and financial issues. The total number of responses (484) exceeds the number of participants (estimated at 203), indicating that multiple responses per person were allowed. Overall, the findings emphasize the need for investments in infrastructure, affordable technology, and instructor training to successfully integrate digital tools into TVET programs in Nigeria.

The data presented in number 6 of table 2 reveals a generally mixed perception among educators and students regarding government support for integrating digital technologies into Technical Vocational Education and Training (TVET) in Nigeria. A combined 27.1% (12.3% very supportive and 14.8% supportive) view the government's efforts positively, while a larger group, 42.9% (29.6% unsupportive and 13.3% very unsupportive), perceive the support as lacking. Notably, 30% of respondents remained neutral, indicating uncertainty or indifference. The mean score of 2.83, slightly below the neutral midpoint of 3, suggests a leaning toward dissatisfaction with government support. The standard deviation of 1.20 shows a relatively wide spread of opinions, reflecting varying experiences or expectations among the respondents.

Number 7 of table 2 presents data from industry professionals on the most in-demand digital skills in the Nigerian construction sector, relevant to developing a digital training framework for TVET. Among the listed skills, Data analysis for construction planning was the most selected, with 61 responses (21.0% of total responses), indicating that 72.6% of respondents considered it essential. Digital Design and Modeling (e.g., BIM) and Use of Project Management tools were equally selected by 60 respondents each (20.7%), showing high demand among 71.4% of participants. Basic Computer-Aided Design (CAD) tools also featured prominently with 45 responses (15.5%) and a 53.6% case percentage. Meanwhile, drone operation for site monitoring and Virtual and Augmented Reality applications received relatively lower emphasis, with 33 (11.4%) and 31 (10.7%) responses respectively, selected by 39.3% and 36.9% of the respondents. The total number of responses (290) exceeds the number of participants due to multiple selections allowed, highlighting a broad recognition of various digital competencies needed to enhance construction workforce sustainability through TVET.

Number 8 of table 2 presents responses from industry professionals regarding whether they believe Technical and Vocational Education and Training (TVET) graduates in Nigeria possess the necessary digital skills required in the construction industry. Out of the total respondents, 31% (26 professionals) answered "Yes," indicating that they believe TVET graduates are adequately equipped with relevant digital competencies. However, a larger proportion, 69% (58 professionals), responded "No," suggesting that a majority of industry stakeholders perceive a significant gap in the digital skillset of TVET graduates. This outcome highlights a pressing need for the development of a targeted digital training framework within TVET programs to better align graduates' competencies with the evolving technological demands of the construction industry for sustainable workforce development.

Number 9 of table 2 summarizes responses from educators, students, and industry professionals regarding strategies to enhance digital training in TVET curricula in Nigeria. Out of 784 total responses, "capacity building for instructors" emerged as the most emphasized strategy, with 252 responses (32.1% of total responses) and 87.8% of participants choosing it. Following closely was "increased funding for digital tools and infrastructure," selected by 246 respondents (31.4% of responses), representing 85.7% of participants. "Regular curriculum updates" and "establishing industry partnerships" received

fewer responses, with 146 (18.6%) and 140 (17.9%) respectively, corresponding to 50.9% and 48.8% of participants. This indicates that while all strategies are valued, there is a clear preference for improving instructor capacity and securing better funding for digital tools and infrastructure, which are seen as the most critical factors for strengthening digital training in TVET.

Number 10 of table 2 presents responses to the question of how important digital skills are for enhancing employability in the construction industry, targeting educators, students, and industry professionals in Nigeria. A significant majority, 153 respondents (53.3%), rated digital skills as extremely important, while 115 respondents (40.1%) considered them important, and only 19 respondents (6.6%) viewed them as moderately important. Notably, none of the participants rated digital skills as slightly important or not important, indicating unanimous recognition of their relevance. The high mean score of 4.47 (on a 5-point scale) and a low standard deviation of 0.62 suggest strong consensus among the respondents about the critical role of digital skills in improving employability within the construction sector. This reinforces the need for a digital training framework in TVET to align with industry demands and support sustainable workforce development.

Number 11 of table 2 presents the results regarding the support for a structured digital training framework for Technical Vocational Education and Training (TVET) in Nigeria, focusing on construction technologies for sustainable workforce development. The survey, which included educators, students, and industry professionals, shows overwhelming support for the framework, with 203 respondents (70.7%) strongly in favor, and 84 respondents (29.3%) supporting it, resulting in a mean score of 4.71. The standard deviation is 0.46, indicating a high level of consensus among the respondents. No respondents were neutral or opposed to the idea, suggesting a strong and uniform belief in the value of this digital training framework for TVET in Nigeria.

Discussion of Findings

The study reveals that the integration and utilization of digital construction technologies in Nigeria's Technical and Vocational Education and Training (TVET) institutions remain suboptimal, with most educators and students reporting moderate to minimal integration (mean = 2.82) and usage (mean = 2.83). This finding aligns with both UNESCO (2023) and Kennedy et al. (2022), who highlight the limited availability and underutilization of digital tools in TVET systems across developing nations, including Nigeria. Basic CAD tools were the most widely available, while more advanced technologies such as BIM, AR/VR, and digital site monitoring tools were significantly underutilized, a situation consistent with the observations of Vararean-Cochisa and Crisan (2025), who attribute this to infrastructural deficits in emerging economies. The perceived effectiveness of current digital training was also low, with only 27.6% of respondents viewing it positively (mean = 2.84), which supports Fowler's (2015) assertion that pedagogical innovation has not kept pace with technological advancement, particularly in areas like VR-based construction education. Industry professionals confirmed that digital competencies, especially in data analysis, BIM, and project management, are highly demanded, reinforcing the argument made by Kraus et al. (2023) that digital fluency is essential for workforce adaptability and productivity in modern industries. Despite this, nearly 70% of professionals believed that TVET graduates lack the necessary digital skills, which mirrors Jain's (2024) and Damek et al.'s (2022) findings that emphasize a significant mismatch between graduate capabilities and workplace expectations. Key challenges identified in the study, such as high costs, inadequate infrastructure, and insufficient instructor training, were also reported by UNESCO (2023) as systemic barriers across low-income countries. Interestingly, resistance to technological change was the least cited barrier, suggesting a growing openness among stakeholders, contrasting with earlier views by Fowler (2015) that emphasized pedagogical resistance.

Finally, the overwhelming support (100%) for a structured digital training framework echoes global best practices, such as Singapore's SkillsFuture initiative, and underscores a unified recognition that digital skills are essential for workforce development and sustainable growth in the Nigerian construction sector.

Theoretical and Practical implications

This study contributes to the existing body of knowledge by highlighting the practical implications of digital construction technologies for TVET training in Nigeria. It provides empirical evidence on the benefits and challenges of digital adoption, offering a framework for future policy and practice.

Conclusion

This study has shown that while digital construction technologies hold immense potential for transforming Technical Vocational Education and Training (TVET) in Nigeria, their current integration and utilization remain limited and inconsistent across institutions. Findings reveal that although basic Computer-Aided Design (CAD) tools are somewhat available, more advanced technologies such as Building Information Modeling (BIM), Virtual Reality (VR), Augmented Reality (AR), and digital site monitoring tools are either minimally integrated or completely absent. This technological gap has resulted in TVET graduates lacking the digital competencies increasingly demanded by the modern construction industry, affecting their employability and the sector's growth potential.

The major challenges hindering digital technology adoption in TVET include inadequate digital infrastructure, high costs of tools, insufficiently trained instructors, and limited government support. Despite these challenges, there is strong consensus among educators, students, and industry professionals on the critical importance of digital skills for enhancing employability and promoting sustainable workforce development in Nigeria. The overwhelming support for the development of a structured digital training framework further highlights a shared urgency for change.

Addressing these challenges requires a multi-stakeholder approach, including increased funding, comprehensive instructor training, continuous curriculum updates aligned with industry trends, and stronger partnerships between TVET institutions and the construction industry. The proposed framework offers a clear, phased pathway to achieving these goals, aiming to modernize TVET curricula, improve student employability, and ensure Nigeria's construction workforce is future-ready.

Integrating digital construction technologies into TVET curricula is not just a necessity for educational relevance, but a strategic move towards sustainable economic growth and technological advancement in Nigeria. Future efforts must prioritize implementation, monitoring, and continuous improvement to realize the full potential of digital transformation in technical education and national development.

Limitations

The scope of this research was constrained by time and resource limitations, which may affect the depth and breadth of data collection and analysis.

Proposed Framework

Based on the findings, the following framework has been proposed. This framework offers a structured, phased, and industry-aligned approach to assist in digitally transforming TVET construction education in Nigeria, ensuring graduates are employable, innovative, and future-ready, thus contributing to sustainable workforce development.

1. **Framework Foundation**

Component	Description
Vision	To produce a digitally skilled, industry-ready construction workforce through TVET modernization.

Component	Description
Mission	To integrate digital construction technologies into TVET curricula, enhancing students' employability and fostering sustainable development.
Guiding Principles	Industry relevance, innovation, inclusivity, sustainability, and continuous improvement.

2. Core Components of the Framework

Core Component	Key Activities
Curriculum Integration	Embed digital construction tools (BIM, CAD, VR/AR, drones, data analysis) into the standard TVET syllabus.
Instructor Capacity Building	Regular, specialized training workshops for TVET instructors on new digital construction technologies.
Infrastructure Enhancement	Provide funding for ICT labs, VR rooms, BIM software licenses, and drone technology setups.
Industry Partnerships	Partner with construction companies for internships, live project collaborations, and technology donations.
Continuous Curriculum Update	Revise and align curricula every 2–3 years based on industry needs and emerging digital trends.
Student-Centered Learning	Use VR simulations, project-based learning, and real-world construction scenarios to teach.
Monitoring and Evaluation	Track digital skill acquisition through assessments, certifications, and feedback from industry employers.

3. Digital Technologies to be Integrated

Digital Tool	Purpose in Training
Building Information Modeling (BIM) (e.g., Revit, ArchiCAD)	3D modeling, project visualization, clash detection.
Virtual Reality (VR) and Augmented Reality (AR) (e.g., Enscape, Hololens)	Immersive site experience, safety training, technical simulations.
Project Management Software (e.g., Primavera P6)	Scheduling, resource planning, cost control.
Digital Site Monitoring Tools (e.g., Drones)	Aerial site surveys, progress tracking, safety monitoring.
Basic CAD Tools (e.g., AutoCAD 2D)	Drafting, basic design skills.
Data Analysis Software	Project planning, efficiency analysis, risk forecasting.

4. Key Strategic Actions

Strategy	Description
Increased Funding	Secure government and private sector investment for tools and infrastructure.
Instructor Professional Development	Provide scholarships, training-of-trainers (ToT) programs, and certification courses in digital technologies.
Technology Awareness	Promote the benefits of digital construction skills among TVET

Strategy	Description
Campaigns	students and educators.
Government Policy Support	Advocate for national TVET digitalization policies and incentives for schools adopting technology.
Pilot Programs	Test the digital training model in selected institutions before national rollout.

Addressing Identified Challenges

Challenge	Framework Solution
Inadequate Infrastructure	Investment in internet, computers, VR equipment, and software.
High Cost of Tools	Seek partnerships, donations, and shared licenses with industry stakeholders.
Lack of Trained Instructors	Implement continuous digital competency development for teachers.
Resistance to Change	Conduct change management workshops and success storytelling from digital adopters.

5. Stakeholder Roles

Stakeholder	Role
Government	Policy formulation, funding, monitoring and evaluation.
TVET Institutions	Implement curriculum changes, manage training delivery, maintain equipment.
Construction Industry Partners	Offer internships, mentorship, equipment donations, and live project opportunities.
Students	Actively engage in digital skill learning and certification programs.
International Bodies (e.g., UNESCO)	Provide technical assistance, frameworks, and best practice models.

6. Implementation Phases

Phase	Activities
Phase 1	Pilot curriculum update, basic equipment procurement, instructor training.
Phase 2	Full deployment in selected institutions, student enrollment, industry collaborations.
Phase 3	Monitoring, feedback collection, and scaling to other institutions.
Phase 4	Nationwide adoption, integration of emerging technologies, continuous system improvement.

7. Success Indicators

Indicator	Measurement
Graduate Employability Rate	Percentage (%) of graduates securing construction sector jobs within 12 months.

Indicator	Measurement
Digital Skills Certification Rate	Percentage (%) of students certified in BIM, CAD, Project Management, etc.
Industry Satisfaction Rate	Percentage (%) of industry employers satisfied with graduate digital competencies.
Curriculum Review Frequency	Number of years between curriculum updates.

Future research directions

Future studies could explore the long-term impact of digital construction technologies on graduates' employability and productivity in the construction industry. Comparative studies across different regions in Nigeria could also provide insights into regional disparities and tailored intervention strategies.

References

Abulrub, A.H.G., Attridge, A. & Williams, M. A. (2011). Virtual Reality in Engineering Education: The Future of Creative Learning. *International Journal of Emerging Technologies in Learning (iJET)*, 6(4), 4–11.

Ajeniweni, P.O., Bamgbowu, S.A., Obasi, I.K., Akinola, B.T. & Nudegbesi, A.M. (2024). The Role Of Vocational Education In Promoting Economic Growth In Nigeria. *Journal Of Economics And Environmental Education*, 8(1), 23-41.

Akindele, L.I. & Olabimtan, R.O. (2023). Bridging The Knowledge Gap in TVET Towards Employability Skills in Nigeria. *Ilaro Journal of Humanities and Management (IJOHAM)*, 3, pp.38-45.

Damek, S., Söbke, H., Weise, F. & Reichelt, M. (2022). (Meta) Competences for Digital Practice: Educational Scenarios for the Workplace of the Future Exemplified by Building Information Modeling Work Processes. Computers and Society, https://doi.org/10.48550/arXiv.2207.01498

Davis, A. (2025). *How Digital Technology is Transforming Construction Education*. Retrieved

March 28, 2025, from https://highways.today/2025/02/12/digital-construction-education/

Fowler, C. (2015). Virtual reality and learning: Where is the pedagogy? *British Journal of Educational Technology*, 46(2), 412-422.

Hoai Le, A.T., Phung, Q., Nguyen, T.X. & Nguyen, T.L. (2022). Establishing a Collaboration Model for BIM Training Program in Technical and Vocational Education and Training (TVET): A Vietnam case study. *IOP Conf. Ser.: Earth Environ. Sci.* 1101, 092032.

IBM Corp. (2019). *IBM SPSS Statistics for Windows, Version 26.0*. Armonk, NY: IBM Corp.

Jain, N. (2024). BIM Drives Digital Integration in Construction. *AZoBuild*. Retrieved March 28, 2025, from https://www.azobuild.com/news.aspx?newsID=23624

Kennedy, G. W., Ekong, M. O., & Okorie, M.N. (2022). Digital Technological Tools for Technical Vocational Education and Training Interactive Learning: Availability and Utilization in Nigerian Universities. *Rivers State University Journal of Education (RSUJOE)*, 25(2), 85-95.

Kerzner, H. (2022). Project management: A systems approach to planning, scheduling, and controlling (13th ed.). Wiley.

Kraus, S., Ferraris, A. & Bertello, A. (2023). The future of work: How innovation and digitalization re-shape the workplace, *Journal of Innovation & Knowledge*, 8(4), 100438. https://doi.org/10.1016/j.jik.2023.100438

Mendes, E., Albeaino, G., Brophy, P., Gheisari, M. & Jeelani, I. (2022). Working Safely with Drones: A Virtual Training Strategy for Workers on Heights. Construction Research Congress 2022, 622-620.

Morley, S. (2025). TVET and AI: Crafting the Future of Vocational Training. Retrieved March 28, 2025, from https://www.worldoftvet.com/blog/tvet-and-ai?utm_source=chatgpt.com

Nagar, M. (2024). Transforming Teaching: The Role of Digital Tools in Modern Education. In P.

Agarwal & N. Khan (Eds.), *The Digital Classroom: Integrating Technology For Effective Learning*. https://doi.org/10.25215/9358793864.21

Onatere-Ubrurhe J.O., Chinyio E., & Georgakis P. (2025) Enhancing Building Technology Education through the Integration of Virtual Reality, *International Journal of Education, Learning and Development*, 13(1), 65-84. https://doi.org/10.37745/ijeld.2013/vol13n16584

Rajamanickam, S., Che' Rus, R., & Abdul Raji, M. N. (2024). Enhancing Tvet For A Digital-Ready Workforce: A Systematic Literature Review. *International Journal of Modern Education*, 6 (23), 865-881.

UNESCO (2023). Enhancing TVET through digital transformation in developing countries. https://unesdoc.unesco.org/ark:/48223/pf0000385988

Vararean-Cochisa, D. & Crisan, E.L. (2025), "The digital transformation of the construction industry: a review", *IIM Ranchi Journal of Management Studies*, 4(1), 3-16. https://doi.org/10.1108/IRJMS-04-2024-0035

Wang, L., Huang, M., Zhang, X., Yan, X., Jin, R., Wanatowski, D., Cheshmehzang, A. & Chohan, N. (2022). Incorporating BIM into the upper-division curriculum of construction engineering and management. *European Journal of Engineering Education*, *48*(3), 482–501. https://doi.org/10.1080/03043797.2022.2112150

Zhong Z, Juwaheer S. (2024). Digital competence development in TVET with a competency-based whole-institution approach. *Vocat Tech Edu*. 1(2). https://doi.org/10.54844/vte.2024.0591

ROLE OF TECHNOLOGICAL INNOVATIONS IN ENSURING SAFETY STANDARDS IN NIGERIA'S CONSTRUCTION INDUSTRY

Odesanmi Atinuke
Abubakar Tafawa Balewa University Bauchi, Nigeria.
odesanmiatinuke@gmail.com

Abstract
The Nigerian construction industry has been facing significant challenges concerning building safety, with frequent incidents of building collapse which has become a great issue in Nigeria because of the impact it inflicts on human lives and properties. The study investigates the roles technological innovations can play towards enhancing the safety standard in building constructions in Nigeria. The article reviews recently developed construction technology and their potential adoption in Nigeria, with a view to creating awareness on how such innovations can transform the industry to ensure better integrity of buildings and reduce Collapse Incidents. The study will, therefore, describe the current state of the Nigerian construction industry, recent technologies like smart materials, Building Information Modelling, and advanced tools for structural analysis in detail. Identifies the barriers to their implementation and recommends how they can become integrated into the Nigerian construction practice.
Keywords*: Technology, Innovation, safety standards, construction industry*

Introduction

The construction industry in Nigeria has continued to be ravaged with various failures, cases of building collapse, resulting in massive loss of lives and property. Most of the time, such disasters are majorly attributed to the use of inferior materials and poor construction methods combined with poor enforcement of building codes and regulations (Oke & Aigbavboa, 2022). The importance the construction industry brings to Nigeria, just like other developed countries, cannot be overemphasized in regard to economic development as well as the aspect of urbanization. This is the sector that is required to provide the infrastructure and buildings needed for the progress of any developed society. However, it is also plagued with many challenges, especially those that regard the safety of the developed structures. In the past, it has been seen to lack the implementation and enforcement of safety regulations, which is greatly attributed to the sustained accidents and fatalities experienced on construction sites in Nigeria (Akinyemi & Adedeji, 2018). A decade in retrospect, innovations of technology are proving to be quite potential solutions in heightening the safety standards of the construction industry in Nigeria. Allowing risks to be mitigated and offering the tools to assist in better compliance with safety regulations, these innovations are far from tools. As a reaction, there is an emerging interest towards technological innovations that can improve the safety standards of buildings and reduce risks related to construction failures.

Technological innovations can be defined in essence as new or modified technology processes, products, or systems that increase mechanisms of efficiency, safety, and productivity (Oke & Aigbavboa, 2017). In construction, such may include advancements in materials, new techniques in carrying out the building process, and digital tools and software that aid in the improvement of project planning and communication. Adoption of this nature would transform the construction industry in Nigeria to be safer and efficient. One of the major technological advancements improving safety in construction is Building Information Modeling (BIM). BIM is an electronic representation of a facility’s physical and functional characteristics. It provides a virtual collaborative platform for architects, engineers, and

other construction experts to work with similar information in an integrated way, alerting them to possible safety hazards before the final implementation stage (Succar, 2009). In Nigeria, the adoption of BIM has been sluggish but is slowly gaining momentum as stakeholders start to realize its gains towards increasing safety and reducing errors on-site (Ibrahim, 2019).

Another very important technological innovation is the use of drones for inspection of sites as well as monitoring the construction. Drones give a bird's eye of the construction site, thus allowing the activities taking place to be monitored to identify any safety risks that may arise. They allow for quick inspection of areas that are hazardous without threatening a workforce person, thereby improving general site safety (Li & Liu, 2018). Drones have found useful applications in terms of site surveys, progress monitoring, and safety monitoring in Nigeria (Adeyemi *et al.,* 2020). The inclusion of wearable technology is transforming the safety level of works in construction sites. For example, wearable technologies may be smart helmets, vests, glasses mounted on the head, among others, with sensing capabilities to monitor vital signs of the worker and to make real-time assessments of the surrounding dangers and thus it notifies the worker in real time so that unwanted incidents are to be averted (Teizer *et al.,* 2013).The technology not only makes the worker safe but also makes data collection and analytics superior for the firm in order to come up with superior strategies for safety measures. In Nigeria, however, wearable technology is still in early phases of adoption, which augurs well for enhanced safety standards (Agbo *et al.,* 2021). In Nigeria, however, while technological innovations hold a lot of promise for inducing high safety standards, equitable challenges hamstring wider adoption: high cost, low technical expertise, and a heavy dose of resistance to change from stakeholders in industry (Oke *et al.,* 2019). The current Nigerian framework for construction safety regulation should be revisited in updating new technologies, especially those that are capable of improving the safety performance in the Nigerian construction industry (Ademola, 2018). All these challenges call for collective efforts to raise awareness and facilitate innovation in the technologies at both governmental and institutional levels.

The Nigerian Construction Industry

Overview

The construction industry is very important to the economic development of Nigeria, considering it makes strong contributions toward infrastructure development and the creation of employment opportunities. It is riddled with a myriad of problems that have served to snuff life out of it. Research findings indicate that the incidence of building collapse in Nigeria is relatively high, with several cases occurring each year caused by the failure of buildings (Ayodeji, 2011). Usually, the failures have taproots located in the woefully inadequate supervision of construction projects, corruption reeking from procurement activities for materials, and failure to adhere to safety standards. The regulatory framework guiding construction works in Nigeria has been portrayed as weak and sparsely enforced. The National Building Code, which prescribed the minimum construction standard, was largely unenforced or poorly implemented, thus making buildings precarious and liable to collapse (Ede, 2010). This situation is further worsened by accountability that is rarely found among construction professionals and an even greater lack of resources that the regulatory bodies may have in order to conduct inspections and enforcement. The rising incidences of building collapse have been fueled by rapid urbanization, which exerts pressure on developers to rush projects through and deliver them cheaply. In most cases, this pressure is achieved by cutting corners through the use of cheaper, poorer quality materials and less skilled labor. In the end, this compromises the structural integrity of such a building and results in catastrophic failures (Windapo & Rotimi, 2012).

The Current State of the Nigerian Construction Industry

The Construction Industry in Nigeria is one of the key sectors providing a great deal toward the economic development of the nation. Being one of the major drivers of infrastructure development and urbanization, it plays a vital role in job creation and economic growth. This important sector has several challenges that make it inefficient and hence unable to expand its potential. This subtopic discusses the current status of the Nigerian construction industry in terms of its economic contributions, main problems, and opportunities.

ECONOMIC CONTRIBUTION

20. Contribution to GDP

The contribution of this sector has been consistent over the years, as it hovers around 4% of the nation's GDP from recent years. Firm government investments in infrastructure, urbanization, and population growth are also among the significant drivers of how the sector contributes to regular requisitions for supplies of housing and commercial buildings, as well as infrastructure projects such as roads, bridges, and airports (National Bureau of Statistics, 2023).

21. Employment Generation

The construction sector has remained a major employer in Nigeria, with millions getting jobs from the industry. A report by the Nigerian Bureau of Statistics confirmed that 5% of the nation's working population is employed by the construction sector, thus making the sector one of the largest employers outside agriculture and It has a high possibility of impacting the general economy by decreasing unemployment and poverty since it is a very labour-intensive industry (National Bureau of Statistics, 2021).

22. Housing and Infrastructure Development

Construction can be said to be dominated by the housing sector. Rapid urbanization and increases in population are major drivers of demand for residential buildings within the sector. Estimates from the World Bank, Nigeria's housing deficit at about 17 million units, thereby making an urgent need for housing development (World Bank, 2023). The government is also focusing much on infrastructure development, which it has worked in some of the current projects concerning the country's transport, energy, and water supply systems.

INDUSTRIAL CHALLENGES

E. Skilled Labour Shortage

One of the significant issues affecting the construction industry in Nigeria is the shortage of skilled manpower. There is a huge labor force, and the industry needs highly trained professionals to meet the quality and efficiency required for the delivery of construction projects (Ebekozien, 2020). This skills gap is affecting the adoption of new technologies and innovative methods of construction.

F. Corruption and Bureaucratic Inefficiencies

Corruption and inefficiencies in bureaucracy are major issues that impact growth within the industry as a whole. More often than not, corrupt practices mar the procurement process for construction projects; hence, the contracts for such projects are awarded to incompetent and unqualified contractors. Consequently, this leads to substandard work, delay in projects, and cost overruns (Alohan, 2021). Besides, the regulatory bottlenecks coupled with a very tedious approval process exacerbate the slowdown in project execution.

G. Financial Challenges

High construction costs and limited access to financing are some of the serious financial challenges facing the construction sector. Fluctuating exchange rates and inflation contribute to the rising costs of building materials, which in turn lead to not very competitive profits in the projects (Adebayo *et al.,* 2021). High costs of accessing credit from the financial institutions imply decreased capacity for most construction firms to be able to undertake and complete large-scale projects.

H. Infrastructure Deficits

Nigeria is still plagued with large infrastructure deficits, despite more recent investments. Poor road networks, inadequate power supply, and lack of modern equipment for current construction work all serve to retard the productivity and timely delivery of projects from the industry (Ogunbiyi *et al.,* 2017). The deficits are also responsible for making construction costlier because companies often have to rely on alternative sources of power and bring in equipment from other countries.

OPPORTUNITIES AND GOVERNMENT INITIATIVES

4. Government Infrastructure Programs

The Nigerian government showed an understanding of the need to develop infrastructural facilities when it ranked infrastructure development as part of its economic development program. The Economic Recovery and Growth Plan (ERGP) identifies ambitious projects designed to close the infrastructure deficit, stimulating economic growth (Federal Government of Nigeria, 2021). This includes investment in transport, energy, and housing—in fact, providing significant opportunities for construction.

5. Public-Private construction

Large-scale infrastructure projects can be financed through Public-Private Partnerships. PPPs can also be applied to close the infrastructure gap and improve quality in construction projects through the injection of private sector expertise and funding (Ibem & Aduwo, 2019). The Nigerian government has, therefore, continued to embrace the adoption of PPPs, with increasing importance in the transport and housing sectors.

6. Urbanization and Population Growth

Nigeria's fast urbanization and population increase offer tremendous opportunities to the construction industry. Projects, therefore, should pour unendingly into the industry with the rising demand for housing, commercial buildings, and infrastructure. The United Nations has projected that by 2050, the population of Nigeria will be somewhere around 400 million making it the third most populous country in the world (United Nations, 2019).

Technological Innovations in Construction

1**. Smart Materials**

Smart materials, like self-healing concerete, and adaptive building material offer potential breakthroughs in the future of improving building safety. For example, self-healing concrete repairs cracks in the concrete, which in extensions enhances the structural integrity of buildings, adding on to the life span of buildings. The introduction and application of this category of material in Nigeria contribute to savings in maintenance costs and prevent minor defects from growing into those kinds of catastrophic failures (Li *et al.,* 2021).

2. **Building Information Modeling (BIM)**

Building information modeling is a digital representation of the physical and functional characteristics of a building. According to Kumar et al. 2024, it gives optimal processes for planning, design, and construction through the provision of the data needed to better inform

decision-making and coordination among all the stakeholders. The application of BIM for these purposes has the potential to enhance safety standards in construction by bringing in accurate designs, reducing errors, and ensuring construction efficiency.

3. **Advanced Structural Analysis Tools**

This would further allow engineers to conduct the simulation of building behavior in different conditions and make them able to establish potential weaknesses long before construction. In fact, such tools are able to optimize design wherein structures are able to meet safety standards and be resilient against environmental stresses, (Wang *et al,* 2023). The adoption of the same into the construction industry in Nigeria would prevent much-anticipated design flaws and generally raise the safety of buildings.

4. **Adoption of Technology in the Nigerian Construction Industry**

Even with all these likely benefits, the adoption process of such technological innovations is slow in Nigeria, considering some of the barriers in place. In this regard, these mainly involve high costs, lack of the needed technical know-how by the industry, and willingness not to change by the stakeholders themselves (Ujene & Ekanem, 2023). Second, it is found that inadequate infrastructural and regulatory settings tend to impair the wide adoption of advanced construction technologies.

Barriers to Adoption

- The cost of resources

Many construction companies in Nigeria do not have the financial muscle to acquire and implement new technologies; this happens to be very expensive. Limited financial resources make it difficult to invest in advanced tools and materials, more so, the SMEs. (Oke & Aigbavboa, 2022).

- Lack of Technical Expertise

One challenge to the adoption of these advanced technologies is the shortage of skilled personnel with the requisite capacity for their operation and maintenance. This would call for training programs and education initiatives in regard to building local capacity so that professionals can ably utilize these innovations.(Ahmed *et al.,* 2023).

- Resistance to change

Organizational and cultural resistance to keeping up with new practices and ideas makes it difficult to modernize the construction industry. Most organizational players in the industry are still grasping the traditional way of undertaking activities because of the comfort and perceived assuredness that these methods will result in quality structures in the end, making it hard to implement inventions and innovations (Smith *et al.,* 2020).

Recommendations on How to Implement

Away from the challenges, though, to improve building safety standards through technological innovation, the following should be envisaged:

1. Government Incentives and Support: The government should provide the needed financial incentives in terms of tax breaks and grants to undertake advanced technologies. Coupled with this, policies and regulations would update to facilitate innovative measures while adhering to safety and related standards.

2. Capacity Building and Training: Initiate training programs and workshops for building professionals to impart operational and maintenance skills for advanced technologies. Liaison with educational institutions to incorporate relevant courses in the curriculum of engineering and building will facilitate the same.

3. Public-Private Partnerships: Partner amongst government entities, the private sector, and international organizations in knowledge transfer and sharing of resources. This kind of

collaboration helps in overcoming financial and technical obstacles that normally impede the adaptation of technological innovations.

4. Awareness and Advocacy: Awareness campaigns should be conducted to bring out the benefits in technological innovations. All doubts, in terms of their reliability and cost-effectiveness, need to be dispelled. Seminars and conferences will bring together groups of stakeholders, who can continuously be engaged in a culture of innovation and improved performance.

Conclusion

Technological changes have the potential to revolutionize the Nigerian construction sector, from building safe standards to reducing the occurrence of collapses. Strategic efforts could hold significant promise in improving quality in construction and safety in buildings. Action to remove barriers and a supportive approach on the part of Nigeria will help harness the full power of technology in creating a more resilient, safer built environment.

References

Adebayo, O., Fagbenle, O., & Oladapo, A. (2021). The impact of inflation on construction project delivery in Nigeria. *International Journal of Construction Management,* 21(5), 451-460.

Ademola, A. (2018). Enhancing safety in Nigeria's construction industry: The role of technology. *Journal of Construction Management,* 5(3), 45-58.

Adeyemi, A., Ojo, S., & Ogunleye, T. (2020). Utilization of drones for enhancing safety in Nigeria's construction sites. *International Journal of Construction Research,* 12(1), 20-35.

Agbo, C. C., Etim, E., & Igwe, A. C. (2021). Wearable technologies and safety improvement in the construction industry: A review. *Journal of Engineering and Technology Research,* 9(4), 67-76.

Ahmed, S., Ali, M., & Khan, R. (2023). Impacts of The integration of smart materials in construction: impacts on safety and sustainability. *Journal of Construction Engineering and Management,* 149(5), 04023011.

Akinyemi, B., & Adedeji, Y. (2018). Safety practices in Nigeria's construction industry: An overview. *Nigerian Journal of Construction Technology and Management,* 11(2), 89-102.

Alohan, F. (2021). Tackling corruption in Nigeria's construction sector. *BusinessDay*. Retrieved from BusinessDay

Ayodeji, O. (2011). An examination of the causes and effects of building collapse in Nigeria. *Journal of Design and Built Environment,* 9(1), 37-47.

Ebekozien, A. (2020). Construction industry development in Nigeria: Challenges and prospects. *Built Environment Project and Asset Management,* 10(3), 403-416.

Ede, A. N. (2010). Building collapse in Nigeria: The trend of casualties in the last decade (2000–2010). *International Journal of Civil & Environmental Engineering* IJCEE-IJENS, 10(06), 32-36.

Federal Government of Nigeria. (2021). Economic Recovery and Growth Plan (ERGP) 2021.

Ibem, E. O., & Aduwo, E. B. (2019). Public-private partnerships (PPPs) in urban housing in Nigeria: The case of Ogun State. *International Journal of Architecture and Urban Development,* 9(2), 13-24.

Ibrahim, M. (2019). Adoption of building information modeling (BIM) in Nigeria: Challenges and prospects. *Journal of Building and Land Development,* 13(2), 55-63.

Kumar, P., Singh, V., & Reddy, K. (2024). Advances in Building Information Modeling (BIM) and its adoption in developing countries. *Construction Technology Review*, 18(2), 102-119.

Li, Z., & Liu, Y. (2018). The application of drone technology in construction safety management. *Procedia Engineering*, 211, 81-89.

Li H., Zhang X., & Shen Q. (2021) Prefabrication and modular construction: A review of recent developments and future directions. *International Journal of Construction Management*, 21(3), 159-178.

National Bureau of Statistics. (2021). Nigerian labor force statistics: Unemployment and underemployment report.

National Bureau of Statistics. (2023). Nigerian Gross Domestic Product Report Q1 2023.

Ogunbiyi, O. E., Goulding, J. S., & Oladapo, A. (2017). An empirical study of the impact of lean construction techniques on sustainable construction in Nigeria. *Journal of Construction Engineering and Project Management*, 7(3), 1-13.

Oke, A. É., & Aigbavboa, C. O. (2017). Sustainable construction technologies: The role of innovation in improving safety standards. *Springer International Publishing.*

Oke, A. E., & Aigbavboa, C. O. (2022). Barriers to adoption of construction technology in Nigeria. *Journal of Construction Innovation*, *22* (4)

Oke, A., Olatunji, O., & Awodele, O. (2019). Barriers to the adoption of safety innovations in Nigeria's construction industry. *Journal of Safety Research and Applications*, 8(1), 12-25.

Smith, J., Williams, P., & Thompson, L. (2020). The technological innovations and their impact on building safety: A global perception. *Building Research and Information*, 48(6), 583-597.

Succar, B. (2009). Building information modeling framework: A research and delivery foundation for industry stakeholders. *Automation in Construction*, 18(3), 357-375.

Teizer, J., Cheng, T., & Fang, Y. (2013). Location tracking and data visualization technology to advance construction ironworkers' education and training in safety and productivity. *Automation in Construction*, 35, 53-68.

Ujene, P. E., & Ekanem, I. A. (2023). Advanced construction technologies adoption and assessment in Nigeria. *Journal of Sustainable Construction*, 9(1), 45-62.

United Nations. (2019). World population prospects 2019: Highlights. Retrieved from United Nations

Wang, Y., Liu, Z., & Zhao, H. (2023). How advanced is the structural analysis technology against the building collapse? *Journal of Structural Engineering*, 149(7), 04023089.

Zhang, Y., Chen, S., & Huang, D. (2024). Exploration of construction technologies and their fit with national building safety requirements in developing countries. *International Journal of Construction Research*, 30(1), 85-102.

Windapo, A. O., & Rotimi, J. O. (2012). Contemporary issues in building collapse and its implications for sustainable development. *Buildings*, 2(3), 283-299.

World Bank. (2023). Nigeria housing sector report. Retrieved from World Bank

DIGITAL SKILLS NEEDED BY BUILDING TECHNOLOGY GRADUATES FOR GLOBAL COMPETITIVENESS IN CONSTRUCTION INDUSTRY IN OYO STATE

Dr. Amos Aderemi AYOOLA
Department of Technology Education,
Faculty of Vocational, Innovation and Engineering Education,
Emmanuel Alayande University of Education, Oyo
ayoolaaa@eauedoyo.edu.ng

Abstract

The building construction industry is gradually tending towards digitalization world-over although the progress seems slow due to limited awareness of the digital skills required for progress by the students of building technology. This study therefore, examined the digital skills needed by building technology graduates for global competitiveness in the building construction industries in Oyo State. There were three objectives and three research questions for the study. A survey research design was adopted for the study. The population for the study consisted of 240 building construction experts. Stratified random sampling was used to select 24 experts from construction firms, 12 building technology lecturers and 57 building technology graduates in Oyo State. A structured questionnaire containing 36 items was used for data collection. The instrument was validated by three experts in Building Technology and measurement and evaluation in Emmanuel Alayande University of Education, Oyo. The data collected were analyzed using mean and standard deviation. The study found that the extent to which graduates acquired digital skills is to a very low extent which must have affected their competitive power at the global market. Hence, the study recommended that management of tertiary institutions should organize regular training and workshops for lecturers to enhance their ability to teach current and emerging digital technologies in the construction field.

Keywords: Building technology graduates, construction industry, digital skills, global competitiveness

Introduction

The entire world is shifting from the analog processes of manufacturing to digital technological system through automation processes using information and communication technology (ICT). Several industries have fully digitalized their operations in various sectors of the global economy of the 21st century. However, digitalization is not fully operational in the building construction industry due to limited awareness of the required digital skills for performance (Leviakangas, Paik, & Moon, 2017, Agarwal, Chandrasekaran, & Sridhar, 2016 and García de Soto, Agustí-Juan, Joss & Hunhevicz, 2022). Digital technological system has the capacity to eliminate many of the inefficiencies associated with the complex construction projects and also processes ability to improve the performance of the construction projects in such areas as safety and quality (Kamaruddin, Mohammad & Mahbub, 2016 and Nassereddine, Veeramani & Veeramani, 2021). Migration from analog to digital technology is however hindered by lack of relevant digital skills which has invariably been affecting individuals as well as building organizations. Several man-hours are lost in Building Construction companies due to malfunctioning of the ICT devices because of a lack of ICT/Digital skills among the workers (Van Deursen & Van Dijk, 2014). Obvious, digital technology skills are needed by the building technology graduates at this moment for employability and global competitiveness.

Building technology is a field of study offered at various levels and each level plays specific functions. As a vocational programme it is aimed at producing technicians who will be able to perform basic functions in erection of building, maintenance and renovation of buildings both in the private and public sectors (National Board for Technical Education - NBTE, 2008). At the University level, it is aimed at producing high calibre professionals with analytical and critical knowledge of the major sectors in contemporary business world to influence the development of a virile economy (CCMAS, 2022). The training of professionals in Building Technology is expected to be thorough and not relying on passing examination with good grades alone but also inculcation of the right values, skills and competences that will result in individuals that will be useful member of the society. The trend world-over is however of technology and not much seems achievable in any field of study without application of relevant digital technology as training tools for the learners without which digital skills needed in the world of work will not be produced.

Digital skills enables the utilization of the digital gadgets, communication appliances and networks to access and manage information (UNESCO, 2018). Likewise, Chaouchi and Bourgeau (2020) upheld that some digital skills are required to use and interact with technology in order to fulfil specific tasks, while others are required to design, create and maintain tools and solutions for different industries. However, in today's world, the basic digital skills needed in the job settings are a little more sophisticated and companies expect numerous employees who possess these skills rather than just a few persons. Such skills are 2D drafting, 3D modeling, Power BI or similar tools for project dashboards and reporting, use of Augmented Reality (AR) and Virtual Reality (VR) for design presentations and construction simulations. It has become obvious that technology is central to our lives and as we become more dependent on digital and internet communications, employees must adapt to changing skill demands.

The construction industry today has witnessed a shift largely from manual operations to the use of basic digital technologies the result of which is skills migration which involves the use of some basic digital technologies such as computer-aided design (CAD), BIM, Internet of Things (IoT), AR, VR, artificial intelligence (AI), drones, laser scanning, 3D printing, big data analytics, geographic information systems (GIS), and robotics (Agrawal; Yadav; Majumdar; Kumar, Luthra & Garza-Reyes, 2023; Chu, Matthews & Love, 2018; Sriyolja, Harwin & Yahya, 2021). These technologies help further achieve modern-era sustainable solutions such as a circular economy within the construction supply chain (Van De Wetering, Dixon & Sexton, 2016). However, they have limited and slower adoption in the construction sector (Agrawal; Yadav; Majumdar; Kumar, Luthra & Garza-Reyes, 2023). Nevertheless, these technologies help eliminate many of the inefficiencies of complex construction projects (Fitriani & Ajayi, 2022), improving the performance of the construction projects such as safety and quality (Chu, Matthews & Love, 2018). Consequently, building technology graduates need to acquire digital skills that will make them to have a competitive advantage over other applicants.

Global competitiveness on the other hand is described as the teaching and receiving procedures that allow students to views issues, events, and opportunities, as well as a profuse knowledge of cultural diversity and languages to operate in different cultural backgrounds from the global perspective, with the aim of putting the students on same level with students from other parts of the globe (Ikpesu, 2017). According to Oko and Wagbara (2022) global competitiveness means the capacity of a goods or service to compete with their counterparts internationally. Thus, the curriculum for students is meant to help them learn, understand, and think internationally. Global competitiveness is therefore abilities to compete favourably with ones contemporaries from the same field of study around the world. According to Oko and Wagbara (2022) global competitiveness means the capacity of

a goods or service to compete with their counterparts internationally. Hence, global competitiveness in the context of this study is the acquisition of abilities that will allow building technology graduates to compete favourably with graduates from the same field of study around the world. Individuals who have the understanding of how to effectively utilize these technological abilities have advantage. As Doyle (2019) noted, employers across industries are looking for digital professionals with a variety of specific skill sets who can fit into modern world of work. However, the above assertion is not too far from what is required in today's construction industry. Therefore, the need for this study.

Statement of the Problem

Upon skills acquired before graduation many building technology graduates still encounter challenges integrating into a technologically driven construction sector. There is a noticeable gap between the skills acquired during academic training and the digital competencies required in the modern building construction industry. These skills mismatch lead to unemployment, underemployment or outsourcing of jobs to more digitally competent foreign professionals. Likewise, a great outcry from employers of labour on the amount spent in retraining graduates to suit the modern work techniques. Meanwhile the objective of the programme is to produce workforce which can fit into the world of work, but the attainment of this objective seems difficult. Hence, the study on digital skills needed by building technology graduates for global competitiveness in building construction industry in Oyo State.

Objectives of the Study

The main objectives of this study is to examine the digital skills needed by building technology graduates for global competitiveness in construction industry in Oyo State. specifically, the study sought to:

i. identify key digital tools and technologies currently used in the global construction industry,

ii. evaluate the adequacy of digital skills training in the Building Technology programme,

iii. recommend digital skills that should be incorporated into the training programs for the building technology to enhance global competitiveness.

Research Questions

The following research questions guided the study.

i. What are the key digital tools and technologies currently in use in the global building construction industry?

ii. How adequate are the digital skills training in the Building Technology programme?

iii. What are the digital skills that should be incorporated into training programs for building technology to enhance global competitiveness?

Methods

Descriptive survey research design was adopted for this study. The population for this study consisted of 240 experts from construction firms, building technology lecturers and graduates in Oyo State. Stratified random sampling was used to select 24 experts from construction firms, 12 building technology lecturers and 57 building technology graduates in Oyo State. The instrument adopted for this study was a structured questionnaire designed

based on existing literature and titled "Digital Skills Requisite Questionnaire (DSRQ)" The questionnaire consisted of 36 items made of two sections; section A sought for demographic data of respondents while section B focused on the research questions. The questionnaire is based on four-point Likert scale. The questionnaire was face and content validated by research experts from Technology Education and Measurement and Evaluation in Emmanuel Alayande University of Education, Oyo. A trial test of the instrument was conducted on 12 experts from building construction firms, 5 building technology lecturers and 14 building technology graduates in Ogun State. Cronbach Alpha was used to analyze the data and 0.91 reliability co-efficient was obtained which is considered high enough for the study. Data was collected by the researcher with the aid of five research assistants who were briefed before administration. Descriptive statistics of Mean and Standard deviation were used to analyze the data collected and Average Mean of 0.25 was considered Agreed while 0.24 was considered Disagreed.

Results

Research Question 1: What are the key digital tools and technologies currently in use in the global construction industry?

Table 1: Respondents mean score on key digital tools and technologies currently in use in the global construction industry

S/N	Items	$\bar{x}$	SD	Decision
1	Building Information Modeling (BIM)	3.12	0.61	Moderately Utilised
2	Computer-Aided Design (CAD)	3.78	0.58	Moderately Utilised
3	Drones / UAVs	2.14	0.62	Not Utilised
4	Geographic Information Systems (GIS)	2.67	0.60	Slightly Utilised
5	Project Management Software (e.g., Primavera, MS Project)	3.54	0.61	Moderately Utilized
6	Construction Management Platforms (e.g., Procore, PlanGrid)	3.01	0.59	Moderately Utilized
7	Augmented Reality (AR) / Virtual Reality (VR)	3.65	0.64	Moderately Utilized
8	Robotics / Automation	2.43	0.58	Not Utilized
9	Artificial Intelligence / Machine Learning	3.51	0.63	Moderately Utilized
10	Internet of Things (IoT) / Smart Sensors	3.56	0.61	Moderately Utilized
11	Digital Twins	3.00	0.61	Moderately Utilized
12	3D Printing	3.51	0.62	Moderately Utilized
13	Mobile Applications for Field Management	3.12	0.63	Moderately Utilized
14	Cloud-Based Document Management	2.12	0.63	Not Utilized
	Average Mean	3.08	0.61	Moderately Utilized

Source: Fieldwork, 2025

Based on the data presented in Table 1, it was evident that eleven items were rated above 2.50 while three items fell below the cutoff point. Item 2 showed the highest mean score of 3.78 which indicated Computer-Aided Design (CAD) as a key digital tool utilized in building construction industry. 3.08 average mean was obtained from the items which

proved that all the respondents reacted positively to the item stated. The results also showed the standard deviation ranged from 0.58 to 0.64 indicating that the respondents were not too far from one another in their responses, proving that the respondents' opinions or responses were similar.

Research Question 2: How adequate are the digital skills training in the Building Technology programme?

Table 2: Respondents mean score on adequacy of digital skills training in the Building Technology programme

S/N	Items	$\bar{x}$	SD	Decision
1	The programme includes sufficient training in digital tools and software used in the construction industry	2.47	0.65	Low Extent
2	I feel confident using digital tools (e.g., AutoCAD, Revit, BIM, simulation software) after completing my training	3.16	0.62	Moderate Extent
3	The digital skills taught are relevant to real-world building technology applications.	3.23	0.62	Moderate Extent
4	The programme keeps pace with emerging digital technologies in construction and design.	3.00	0.64	Moderate Extent
5	There is adequate hands-on experience or practical application of digital tools.	3.11	0.63	Moderate Extent
6	The instructors are well-equipped to teach digital tools and software effectively.	2.74	0.62	Slight Extent
7	I had access to the necessary digital infrastructure (software, hardware, internet) for learning.	3.01	0.63	Moderate Extent
8	Collaboration tools and project management platforms (e.g., Microsoft Project, BIM 360) are adequately covered.	2.89	0.65	Slight Extent
9	Assessment and feedback methods reflect the use and understanding of digital skills.	3.34	0.61	Moderate Extent
10	The programme has improved my employability in digital areas of building technology.	2.88	0.64	Slight Extent
	Average Mean	2.98	0.63	Slight Extent

Source: Fieldwork, 2025

Data presented in Table 2, showed the mean score of the data from the respondents' view about the adequacy of digital skills training in the Building Technology programme. Item 9 showed the highest mean score of 3.34 which stated that assessment and feedback methods reflect the use and understanding of digital skills. Item 1 showed the lowest mean score of 2.47 which indicated that programme includes sufficient training in digital tools and software used in the construction industry. The average mean score of 2.98 was obtained meaning that the respondents agreed positively to item statement. The results also showed the standard deviation ranged from 0.61 to 0.65 indicating that the respondents were not too far from one another in their responses, proving that respondents' opinions or responses were similar.

Research Question 3: What are the digital skills that should be incorporated into training programs to enhance global competitiveness?

Table 3: Respondents mean score on digital skills that should be incorporated into training programs to enhance global competitiveness

S/N	Items	$\bar{x}$	SD	Decision
1	2D drafting and technical drawing	3.39	0.79	Moderately

				Recommended
2	3D modeling and Building Information Modeling (BIM)	3.44	0.75	Moderately Recommended
3	Conceptual design and 3D visualization	3.41	0.74	Moderately Recommended
4	Understanding of collaborative BIM workflows and data sharing	3.04	0.78	Moderately Recommended
5	Gantt charts, task scheduling, and resource allocation	3.12	0.77	Moderately Recommended
6	Digital project tracking and reporting	3.31	0.76	Moderately Recommended
7	Integration of GIS data into planning and design	3.43	0.78	Moderately Recommended
8	Power BI **or similar tools** for project dashboards and reporting	3.21	0.76	Moderately Recommended
9	Quantitative data interpretation for decision-making	3.45	0.78	Moderately Recommended
10	**Visual scripting** in tools like **Dynamo** for Revit	3.21	0.77	Moderately Recommended
11	Use of Augmented Reality (AR) and Virtual Reality (VR) for design presentations and construction simulations	3.65	0.75	Highly Recommended
12	Safe use of online platforms and secure sharing of files	2.87	0.77	Moderately Recommended
	Average Mean	2.73	0.76	Moderately Recommended

Source: Fieldwork, 2025

Based on the data presented in Table 3, it was evident that all the twelve items were rated above 2.50. Item 11 showed the highest mean score of 3.65 which stated that use of Augmented Reality (AR) and Virtual Reality (VR) for design presentations and construction simulations are highly recommended. 2.73 average mean was obtained from the items which proved that all the respondents reacted positively to the stated recommendations. The results also showed the standard deviation ranged from 0.74 to 0.79 indicating that the respondents were not too far from one another in their responses, proving that the respondents' opinions or responses were similar.

Discussion of Findings

Results emanated from the study revealed some essential digital tools required in the construction industry. The implication is that for building technology graduates to meet up with the requirements of the world of work, they must be equipped with the basic skills needed to operate certain equipment and tools. Agrawal *et al.,* 2023; Chu, Matthews & Love, 2018; Sriyolja, Harwin & Yahya, 2021 posited that almost every sector of life has been dominated with the use of modern technology and this is not exempting construction industry. Therefore, for an individual to cope with the modern trends, he or she has to be knowledgeable in the basic skills required in the use of digital technologies.

Findings also revealed that although the programme is with an inclusion of information and technology which gives birth to digital technologies but the rate at which these skills are imparted into learners is to a slight extent as against a very high extent required for global competitiveness. This finding is supported by Ikpesu (2017) who emphasized that basic technology skills are essential in the construction industry as different machines and tools are being developed to enhance building sustainability. Without the basic skills required of

today's graduates, those tools and equipment will just become a waste as the will not be able to perform optimally for the purpose of their procurement.

Also, study revealed that the use of Augmented Reality (AR) and Virtual Reality (VR) for design presentations and construction simulations enhance presentations in diverse of ways. This is because of their abilities to present 2D drawings in 3D for better visualization among others skills. This finding is supported by Chaouchi and Bourgeau (2020); Fitriani and Ajayi (2022) who posited that 3D modelling enhances client interest and understanding of presentations hence, better presentation resulting from the use of modern technologies a significant skill among others required of building technology graduates to enable them function effectively in the modern competitive market.

Conclusion

The study concluded that for building technology graduates to attain global competitiveness in the construction industry, there is a critical need to equip them with relevant digital skills such as 3D modelling, gantt charts, task scheduling, Augmented Reality (AR) and Virtual Reality (VR) for design presentations and construction simulations among others, as current educational programme provide limited exposure, thereby necessitating a strong partnerships between academic institutions and industry stakeholders.

Recommendations

i. Curriculum planners should revise building technology curriculum to include comprehensive training in essential digital tools such as AutoCAD, Revit, BIM, Primavera, Microsoft Project and GIS technologies. Likewise, management of tertiary institutions should make provision for the availability of these technologies through external sources such as alumni, philanthropist among others for real-world classroom practice.

ii. Lecturers should be placed on hands-on training and practical sessions using real-world software and simulation tools to ensure students gain proficiency, not just theoretical knowledge.

iii. Management of tertiary institutions should organize regular training and workshops for lecturers to enhance their ability to teach current and emerging digital technologies in the construction field.

References

Agrawal, R.; Yadav, V.S.; Majumdar, A.; Kumar, A.; Luthra, S.; Garza-Reyes, J.A. (2023). Opportunities for disruptive digital technologies to ensure circularity in supply Chain: A critical review of drivers, barriers and challenges. Comput. Ind. Eng. 178, 109140.

Agarwal, R.; Chandrasekaran, S. and Sridhar, M. (2016) Imagining Construction's Digital Future.*McKinsey*.https://www.mckinsey.com/industries/capital-projects-and-infrastructur e/our-Insights/imagining-constructions-digi- tal-future.

CCMAS (2022). Education. http://creativecommons.org/licenses/by-sa/3.0/igo/

Chaouch, H. & Bourgeau, T. (2020). Will all jobs require programming skills in the growing digital society? Retrieved from: https://academy.itu.int/sites/default/files/media2/file/Digital%20Skills%20Insights%202020.pdf

Chu, M., Matthews, J., & Love, P. E. (2018). Integrating mobile Building Information Modelling and Augmented Reality systems: An experimental study. Autom. Constr, 85, 305–316.

Doyle, L. (2019). What is digital communication and why are skilled professionals in such high demand? Retrieved form

https://www/northeastern.edu/bachelorscompletion/news/what-is-digital-communication/

Federal Republic of Nigeria (FRN, 2013). National policy on education. (6th ed.). Nigerian Educational Research and Development Council (NERDC) Press.

Fitriani, H.; Ajayi, S. (2022). Preparing Indonesian civil engineering graduates for the world of work. Ind. High Educ., 36, 471–487.

García de Soto, B., Agustí-Juan, I., Joss, S. and Hunhevicz, J. (2022) Implications of Construction 4.0 to the workforce and organizational structures. Int. J. Constr. Manag. 22, 205–217. https://doi.org/10.1080/15623599.2019.1616414

Ikpesu, C. (2017). Globalizaing business education curriculum experiences in Nigeria higher education for enhanced students' employability. European Journal of Business and innovation Research. 5(5) 47-57

Kamaruddin, S.S.; Mohammad, M.F.; Mahbub, R. (2016) Barriers and Impact of Mechanisation and Automation in Construction to Achieve Better Quality Products. Procedia Soc. Behav. Sci. 222, 111–120. https://doi.org/10.1016/j.sbspro.2016.05.197.

Leviakangas, P., Paik, S.M. & Moon, S. (2017). Keeping up with the pace of digitization: The case of the Australian construction industry. *Technol. Soc.* 50, 33–43. https://doi.org/10.1016/j.techsoc.2017.04.003.

National Board for Technical Education (2008). Curriculum and course specifications for HND in building technology. Kaduna: NBTE Press.

Nassereddine, H.; Veeramani, A.; Veeramani, D. (2021) Exploring the Current and Future States of Augmented Reality in the Construction Industry; Springer International Publishing: Cham, Switzerland, . https://doi.org/10.1007/978-3-030-48465-1_31.

Oko, M.C. & Wagbara, S.O. (2022). Digital skills needed by business education graduate for global competitiveness in entrepreneurship in Ebonyi State. Nigeria Journal of Business Education, 9(1), 225-230.

Sriyolja, Z.; Harwin, N.; Yahya, K. (2021). Barriers to Implement Building Information Modeling (BIM) in Construction Industry: A Critical Review. IOP Conf. Ser. Earth Environ. Sci., 738, 012021.

UNESCO (2018). Digital skills critical for jobs and social inclusion. Retrieved from: https://en.unesco.org/news/digital-skills-crotical-jobs-and-social-inclusion

Van De Wetering, J.; Dixon, T.; Sexton, M. (2016). Smart Cities, Big Data and the Built Environment: What's Required. In Proceedings of the 23rd Annual European Real Estate Society Conference, Regensburg, Germany, 8–11 June 2016.

Van Deursen, A. & Van Dijk, J. (2014) Loss of labor time due to malfunctioning ICTs and ICT skill insufficiencies. Int. J. Manpow. 35, 703–719. https://doi.org/10.1108/IJM-07-2012-0102.

INTEGRATING DIGITAL SKILLS IN UNIVERSITY WOODWORK TECHNOLOGY CURRICULUM FOR DIGITAL ECONOMY DEVELOPMENT IN SOUTHWEST NIGERIA

Dr. Ibukun Francis ADEAGBO
Department of Technology Education,
Faculty of Vocational, Innovation and Engineering Education,
Emmanuel Alayande University of Education, Oyo
adeagboif@eauedoyo.edu.ng

Abstract
This study determined the integration of digital skills in university woodwork curriculum for digital economy development in southwest Nigeria. Four research questions guided the study. The study adopted descriptive survey research design. The population of the study comprised 168 experts, composed of 9 woodwork technology lecturers and 159 final year students specializing in woodwork technology in the six states in southwest Nigeria. Total enumeration technique was used to select the entire population because of manageable size. A 36 - item structured questionnaire validated by three experts from Department of Technology Education, Emmanuel Alayande University of Education, Oyo was adopted for the study. The reliability of the instrument was established using trial-testing thereafter analyzed using Cronbach Alpha which yielded coefficient value 0.87. Data were analyzed using mean, standard deviation. Findings showed that digital skills were highly needed in university woodwork technology programme for digital economy development. It was further revealed that the identified digital skills were suitable for preparing undergraduates for digital economy development. The study concluded that the curriculum of woodwork technology should accommodate digital skills that are critical to the growth of the nation's economy. Based on the findings, it was recommended among others that curriculum of woodwork technology should be reviewed from time to time to accommodate required digital skills. This will enhance digital skill acquisition of students for job creation.
Keywords: Digital Economy, Digital Skills, Curriculum, Woodwork Technology

Introduction
Increase in youth population and digital transition represent a huge opportunity to bolster Nigerian economy. The Sustainable Development Goal (SDG) Target 4.4 requires countries to substantially increase the number of young people and adults who have relevant skills, including technical and vocational skills for employment, decent jobs and entrepreneurship by 2030. Tracking progress in digital skills, indicator 4.4.1 measures the size of youth and adult populations who have the information technology skills to give them a path to better jobs in a digital economy. Digital economy as defined by Ndubuisi, Ezeani and Ile (2022) referred to an economy business that sell goods and services via the internet and digital platforms that connect spare capacity and demand. Digital economy has enabled fast revenue growth in many sectors of life including furniture industry and it is estimated to make up around 5% of global GDP and 3% of global employment (Bukht & Heeks, 2017). Consequently, the term digital economy can be described as a wide area of economic

activity that includes all employment in the digital sector as well as digital occupations like woodworking technology.

Woodwork technology is a specialized area within technology education programme offered in university that focuses on the design, construction and finishing of wood-based products using a variety of tools, machines and techniques (Adeagbo, 2019). As an applied discipline, it bridges traditional craftsmanship with modern production methods, equipping learners with both theoretical knowledge and practical skills necessary for careers in carpentry, joinery, furniture making, cabinetry and related sectors of the construction and manufacturing industries. Woodwork technology is designed to provide students with a strong foundation in wood science, materials technology, machine operations, product design and workshop safety. In line with the CCMAS the curriculum often includes elements of engineering drawing, production planning, cost estimation and project management to develop well-rounded professionals capable of functioning in industrial settings, entrepreneurial ventures or academic and research roles. In addition, Efanimjor and Okolocha (2020) stated that curriculum is responsible for the systematic organisation of formal and informal experiences geared towards facilitating the development of the cognitive, physical, psychomotor and socio-emotional potentials of students. Meanwhile, Oguejiofor (2020) posited that part of the demands of the twenty-first century abilities are not met by the curricula offered at the tertiary institution level. In agreement, Adeagbo (2019) claimed that Nigerian woodworking technology differs from the global digital world in that the majority of its products lack the necessary skills for the workplace and some are still sent for retraining at an extra expense by their employers. This discrepancy, however, illustrates a complete divergence between the demands of the labor market and what academic institutions have to offer. Here, the difficulty is in making sure that the curriculum and delivery system produce adequate results that can compete on a worldwide basis in the job market. This can only be accomplished by incorporating digital skills into woodworking technology pedagogy.

Digital skills are a set of technological abilities used to access and manage digital information. UNESCO (2018) defined digital skills as a range of abilities required to use digital devices, communication applications and networks to access and manage information. It enables people to create and share digital content, communicate, collaborate and solve problems for effective and creative self-fulfillment in life, learning, work and social activities at large. Ferrari (2013) saw digital skills as the ability to critically analyse and assess digital information, problem solving through the use of digital tools, creation and recreation of content and so forth. The International Telecommunication Union (ITU, 2020) defined digital skills as a set of technological abilities that may be fully or partially acquired before entering the world of work. In the context of this study, digital skills are the abilities of using digital technologies to transform existing traditional and non-digital business processes and services or creating new ones, to meet evolving market and customer expectations. Some digital skills are required to use and interact with technology in order to fulfil specific tasks, while others are required to design, create and maintain tools and solutions for different industries.

In the digital marketplace, digital skills form the backbone of productivity, learning digital skills is easily possible through smart education. Smart education is the combination of

advanced technologies such as virtual reality, artificial intelligence (AI), cloud computing, virtual reality (VR), mobile learning tools which is very much internet dependent as well. Digital skills as part of smart education leverages information and communication technology (ICT) to boost learning through personalised, dynamic, efficient methods. The main idea of this is to employ digital tools, preferences and platforms to acquire digital skills, this approach is targeted at promoting lifelong learning to foster creativity and innovation. According to Alyoubi (2015) in order for students to effectively participate in the growth of the digital economy, they must possess digital abilities. According to The World Economic Forum (2018) digital skills are necessary for the growth of all economic sectors, including the information and communication technology, construction, tourism, health, agriculture, finance, transportation and education sectors. In support of the aforementioned, the ITU (2020) declared that digital skills are essential for engaging in the labor market and suggested that they be incorporated into education and training to allow people to fully engage in the modern digital economy, whether as technology experts, executives of companies that use digital technology or employees in jobs that use digital technology throughout the economy. In support, Okoye (2017) said that in order to prepare students for the competitive global labor market, basic ICT skills had to be incorporated into higher education programmes such as woodwork technology curriculum. According to the Organization for Economic Co-operation and Development (OECD) (2015) in order for higher education to serve as a leader in the provision of digital skills, it is imperative that both teachers and students receive top-notch training standards and that digital skills be ingrained throughout the entire educational and training process. According to Brandes and Zobrist (2017) digital knowledge offers platforms that facilitate communication and teamwork. It encourages innovation and creates chances to learn about significant concepts.

Anecdotal evidence suggests that many university woodwork technology programmes may still be operating with outdated curricula that inadequately reflect these digital realities (Adeagbo, 2019; Adeagbo & Ayano, 2019; Ayoola et. al., 2023). This disconnect poses a significant barrier to both employability and the broader goal of economic transformation through digital integration. Likewise, several challenges hinder the adoption of digital technologies in woodwork technology programme. Key among these is the lack of adequate funding, which limits the procurement of modern digital equipment such as CNC machines and CAD software (Ayoola *et al.,* 2023). Additionally, many institutions face shortages of trained personnel who can teach and manage digital tools effectively (Adedeji *et al.,* 2024). Outdated curricula, insufficient infrastructure and limited access to electricity and internet connectivity further constrain integration efforts. These challenges collectively slow down the transition from traditional woodwork methods to digitally-enhanced practices, reducing the competitiveness and relevance of graduates in the modern job market. However, to enhance woodwork technology programme align with digital economy standards, institutions must prioritize curriculum reform that integrates digital skills. Investment in modern equipment and infrastructure is essential, alongside the training and upskilling of instructors in digital technologies (Adeagbo, 2019). Collaborations with industry stakeholders can provide practical exposure, internships and access to current digital trends. Additionally, incorporating online learning platforms and digital resources can broaden students access to updated knowledge and global best practices (Adedeji *et al.,* 2024).

These strategies will help produce graduates who are competent, innovative and ready to contribute meaningfully to the digital economy.

Statement of the Problem

Despite global trends promoting digital transformation in technology education, many universities in Southwest Nigeria continue to deliver woodwork technology programme using outdated lecture notes, methods, tools and equipment. This disconnect results in a skills gap, limiting graduates' capacity to thrive in the digital economy. Without intervention, this lag may hinder national development, reduce innovation and limit youth employment potential in modern furniture design and manufacturing.

Objectives of the Study

The main objective of this study is to assess the integration of digital skills in university woodwork technology programme for digital economy development in southwest Nigeria. Specifically, the study sought to;

i. examine the current integration of digital skills in the woodwork technology programme of universities in Southwest Nigeria.
ii. evaluate the effectiveness of existing digital skill components in preparing students for the digital economy.
iii. identify challenges hindering the adoption of digital technologies in woodwork technology programme
iv. propose strategies for enhancing the woodwork technology programme to meet digital economy standards.

Research Questions

The following research questions guided the study.

i. What digital skills are currently incorporated into university woodwork technology programme in Southwest Nigeria?
ii. How well do these digital skills align with the requirements of the digital economy?
iii. What are the challenges in the adoption and implementation of digital tools in woodwork technology programme?
iv. What are the strategies that can be adopted in woodwork technology programme to meet digital economy standards?

Methodology

Descriptive survey research design was adopted for this study. The population for this study consisted of 168 experts, composed of 9 woodwork technology lecturers and 159 final year students specializing in woodwork technology in the six states in southwest Nigeria. Total enumeration technique was used to select the entire population because of manageable size. The instrument to adopted for this study was a structured questionnaire designed based on existing literature and titled "Integration of Digital Skills Questionnaire (IDSQ)" The questionnaire consisted of 36 items made of two sections; section A sought for demographic data of respondents while section B focused on the research questions. The questionnaire is based on four-point Likert scale of Strongly Agreed (SA – 4); Agreed (A – 3); Disagreed (D – 2) and Strongly Disagreed (SD – 1). The questionnaire was face and content validated by three research experts from Department of Technology Education, Emmanuel Alayande University of Education, Oyo. A trial test of the instrument was carried out on 5 woodwork

technology lecturers and 36 woodwork technology final year students in two Universities in South-South Nigeria which include University of Benin and Nnamdi Azikiwe University, Awka. Cronbach Alpha was used to analyzed the data and 0.87 reliability co-efficient was obtained which is considered high enough for the study. Data was collected by the researcher with the aid of six research assistants who were briefed before administration. Descriptive statistics of Mean and Standard deviation was used to analyzed the data collected and Average Mean of 0.25 was considered Agreed while 0.24 was considered Disagreed.

Results

Research Question 1: What digital skills are currently incorporated into university woodwork technology programme in Southwest Nigeria?

Table 1: Respondents mean score on digital skills currently incorporated into university woodwork technology programme

S/N	Which of the following digital skills are covered in your coursework	$\bar{x}$	SD	Decision
1	Application in the use of Computer-Aided Design (CAD)	3.46	0.77	A
2	Ability to operate Computer Numerical Control (CNC) machine operation	2.05	0.84	D
3	Skills in digital woodwork simulations or virtual labs	2.42	0.81	D
4	Application in 3D modeling and rendering	3.09	0.75	A
5	Use of woodwork project management software (e.g., Microsoft Project)	3.21	0.67	A
6	Internet research skills for woodwork design	3.78	0.69	SA
7	Ability to use online collaboration tools (e.g., Google Drive, Trello)	2.32	0.68	D
8	Ability to use digital fabrication tools (e.g., laser cutters, 3D printers)	1.03	0.77	SA
9	Skills in digital marketing	2.84	0.65	A
	Average Mean	**2.68**	**0.73**	**A**

Source: (Author, 2025)

Results from Table 1 indicated that four out of nine items had a mean score below 2.50 cut off point. Item 6 had the highest mean score of 3.78 which revealed skills in the use of internet for woodwork design. Average mean score of 2.68 was obtained indicated that the respondents reacted positively to the statement items. Likewise standard deviation mean score ranged from 0.67 to 0.84 was obtained meaning that the respondents were not too far from their respective opinion.

Research Question 2: How well do these digital skills align with the requirements of the digital economy?

Table 2: Respondents mean score on effectiveness of existing digital skill components

S/N	effectiveness of existing digital skill components	$\bar{x}$	SD	Decision
A	Perceived Relevance of Digital Skill Components			
1	The digital skills taught in my programme are aligned with current industry needs.	2.73	0.81	A
2	The curriculum covers emerging technologies relevant to the digital economy (e.g., AI, data analytics, cloud computing).	2.65	0.73	A
3	Students believe the digital skills learnt will be useful in my future career.	3.43	0.78	A
4	The program addresses both technical and soft digital skills (e.g., online collaboration, digital communication).	2.52	0.75	A
5	Students regularly use the digital tools learnt in class in real-world or internship settings.	2.09	0.78	D
B	Curriculum and Instructional Design			
6	Digital skills are integrated across multiple subjects in the curriculum.	2.11	0.77	D
7	The learning materials are up-to-date with the latest digital trends and tools	1.07	0.80	SD
8	Instructors are knowledgeable about current digital technologies.	2.19	0.81	D
9	There are sufficient hands-on opportunities (labs, projects, simulations) to practice digital skills.	1.32	0.79	SD
10	The programme encourages innovation and critical thinking using digital tools.	2.45	0.74	D
C	Practical Application and Employability			
11	Students feel confident using digital tools commonly used in the workplace (e.g., Excel, programming languages, project management tools).	2.65	0.76	A
12	Students have been taught how to manage digital data securely and ethically.	2.14	0.77	D
13	The programme has helped students build a strong digital portfolio or resume	2.32	0.78	D
14	Students understand how digital technologies can be used to solve real-world business problems.	2.87	0.79	A
15	Students are aware of the digital skill requirements for jobs in my field of study.	3.01	0.80	A

D	Support and Infrastructure			
16	The institution provides adequate access to digital tools and resources (e.g., software, hardware, internet).	1.00	0.75	SD
17	Technical support and guidance are available when learning digital skills.	2.34	0.76	D
18	Students had opportunities to participate in digital skill workshops, bootcamps or online courses.	3.04	0.77	A
19	Career services provide guidance on digital careers and skill development for students	3.21	0.78	A
20	The institution partners with industry to ensure training reflects real-world digital needs.	3.12	0.74	A
E	**Overall Satisfaction and Improvement**			
21	Overall, students are satisfied with the digital skills training provided.	2.21	0.76	D
22	Lecturers can recommend improvements in the way digital skills are taught.	3.48	0.78	A
23	Students feel better prepared for the digital economy than when I started the programme	2.67	0.81	A
24	There is a continuous effort by the institution to update digital skill training	3.51	0.77	SA
25	Students would like to receive more advanced or specialized digital skill training in the future.	3.84	0.74	SA
	Average Mean	2.55	0.77	A

Source: (Author, 2025)

Result in Table 2 revealed that all the twenty-five items listed with mean ratings ranging from 1.00 - 3.84 with a average mean of 2.55. This showed that the respondents are of the opinion that the effectiveness of existing digital skill components align with the requirements of the digital economy. The standard deviations for all the items are within the same range showing that the respondents were homogeneous in their opinions.

Research Question 3: What are the challenges in the adoption and implementation of digital tools in woodwork technology programme?

Table 3: Respondents mean score on challenges in the adoption and implementation of digital tools in woodwork technology programme

S/N	challenges in the adoption and implementation of digital tools in woodwork technology programme	$\bar{x}$	SD	Decision
1	There is adequate internet and power supply to support digital tools.	2.13	0.67	D
2	Instructors are adequately trained to use digital	2.45	0.72	D

	tools in teaching.			
3	Students receive sufficient training on how to operate digital tools.	2.34	0.73	D
4	There are regular workshops or capacity-building sessions for digital tool usage.	3.01	0.64	A
5	The programme receives sufficient funding for technology upgrades	2.14	0.68	D
6	The cost of purchasing and maintaining digital tools is a major challenge.	3.33	0.68	A
7	The curriculum fully integrates digital tool usage in woodwork practices.	2.52	0.71	A
8	Institutional policies support digital transformation in vocational education	3.01	0.70	A
9	There is resistance from staff or students in adopting new digital tools.	3.52	0.68	SA
10	Fear of job loss or redundancy affects the acceptance of digital tools	3.54	0.69	SA
11	There is adequate technical support when digital tools malfunction.	2.19	0.71	D
12	Spare parts and technical expertise are easily accessible for maintenance.	2.23	0.70	D
	Average Mean	2.70	0.69	A

Source: (Author, 2025)

Data in Table 3 showed that all the twelve items listed with mean ratings ranging from 2.13 – 3.54 with a cluster mean of 2.07. This indicated that the respondents are of the opinion that the statements items hinders' the adoption and implementation of digital tools in woodwork technology programme. The standard deviations for all the items are within the same range of 0.64 – 0.73 showing that the respondents were homogeneous in their opinions

Research Question 4: What are the strategies that can be adopted in woodwork technology programme to meet digital economy standards?

Table 4: Respondents mean score on strategies that can be adopted in woodwork technology programme to meet digital economy standards

S/N	strategies that can be adopted in woodwork technology programme to meet digital economy standards	$\bar{x}$	SD	Decision
1	Update the curriculum to include digital design and manufacturing	3.35	0.74	A
2	Introduce and train students in the use of **Computer-Aided Design (CAD)** software like AutoCAD, Fusion 360, or SketchUp.	3.56	0.71	SA
3	Provide continuous professional development (CPD) in digital teaching tools and platforms,	3.67	0.73	SA

	woodworking technologies			
4	Partner with modern woodworking industries and digital fabrication labs for curriculum input to match industry trends	3.71	0.69	SA
5	Upgrade facilities to include digital design labs with modern computers and licensed software.	3.51	0.71	SA
6	Encourage digital entrepreneurship in custom furniture design and online marketing.	3.45	0.72	A
7	Support student-led innovations in eco-design, modular systems, or smart furniture.	3.19	0.73	A
8	Train students on using digital tools for pricing, inventory, and customer relationship management (CRM).	3.76	0.70	SA
9	Develop institutional policies for digital transformation in technical education.	3.45	0.71	A
10	Include digital economy goals in strategic plans and programme evaluation metrics.	3.01	0.72	A
11	Seek government and private funding for technology adoption and capacity building.	3.21	0.70	A
	Average Mean	3.44	0.71	A

Source: (Author, 2025)

Data presented in Table 4, showed the mean score of the data from the respondents' view about the strategies that can be adopted in woodwork technology programme to meet digital economy standards. Item 8 showed the highest mean score of 3.76 which indicated the training of students on digital tools for pricing, inventory, and customer relationship management (CRM). The average mean score of 3.44 was obtained meaning that the respondents agreed positively to item statement. The results also showed the standard deviation ranged from 0.69 to 0.74 indicating that the respondents were not too far from one another in their responses, proving that respondents' opinions or responses were similar.

Discussion of Findings

The study findings revealed that although digital skills are incorporated into the woodworking technology coursework, their coverage is inconsistent across different areas. Some digital competencies, such as internet use for woodwork design, are well integrated and recognized by respondents, while other important digital skills receive less attention, falling below the desired proficiency levels. This uneven coverage suggests that the curriculum does not yet provide a balanced or comprehensive digital skills education. This finding is supported by Adeagbo (2019); Brandes and Zobrist (2017) and Ndubuisi, Ezeani and Ile (2022) who highlighted the need for curriculum development to ensure all relevant digital competencies are adequately addressed to better prepare students for the demands of the digital economy.

The study findings also indicated that respondents generally believe the existing digital skill components in the woodworking technology programme are effectively aligned with the demands of the digital economy. Their positive feedback suggests that the current

curriculum sufficiently addresses key digital competencies necessary for students to thrive in a digitally-driven market. This alignment reflects an awareness among respondents that the digital skills taught are relevant and contribute meaningfully to preparing graduates for participation in the evolving digital economy. However, while the overall perception is favorable, Bukht and Heeks (2017) and Okoye (2017) noted that the findings also implies the need for continuous updates and enhancements to maintain this alignment as technological advancements and market needs evolve. The study findings revealed that respondents believe certain factors identified in the statement items act as significant barriers to the adoption and implementation of digital tools within the woodwork technology program. These perceived hindrances suggest challenges such as limited resources, insufficient training, or infrastructural gaps that prevent full integration of digital technologies (Adeagbo, 2019; Adeagbo & Ayano, 2019; Ayoola et. al., 2023).

The study findings suggested that adopting targeted strategies such as training students on digital tools for pricing, inventory management, and customer relationship management (CRM) can significantly enhance the woodworking technology program's alignment with digital economy standards. Equipping students with these practical digital skills not only improves their operational efficiency but also prepares them to manage business processes more effectively in a competitive market. This is supported by the words of Adeagbo (2019) and Ndubuisi, Ezeani and Ile (2022) that by integrating such training into the curriculum, universities can foster a more business-savvy and technologically proficient workforce, ultimately driving innovation and growth within the woodworking sector and supporting broader economic development goals.

Conclusion

Integrating digital skills into university woodworking technology programs is essential for aligning educational outcomes with the demands of the rapidly evolving digital economy in southwest Nigeria. This study highlights that embedding competency such as computer-aided design (CAD), digital fabrication techniques and software literacy within the woodworking curriculum can significantly enhance students' technical proficiency and employability. By fostering a synergy between traditional craftsmanship and modern digital tools, universities can cultivate a new generation of skilled artisans and technologists capable of innovating and competing in both local and global markets. Furthermore, this integration supports sustainable economic growth by enabling graduates to leverage digital platforms for marketing, production efficiency and value addition.

Recommendations

i. curriculum of woodwork technology should be reviewed by the curriculum planners from time to time to accommodate required digital skills needed by the students as this will enhance digital skill acquisition of students for job creation.
ii. Universities management should engage, encourage and sponsor their woodwork lecturers and technologist for re-training programmes to update their ICT knowledge, skills and competencies to effectively utilize the resources for quality instructional delivery in their programme.
iii. Management of tertiary institutions should organize regular training and workshops for lecturers to enhance their ability to teach current and emerging digital technologies in the woodwork technology.

iv. Universities management should enter into partnership with ICT manufacturing organizations to assist in improving the supply of the resources for their academic programmes towards qualitative teaching and learning process.

References

Adeagbo, I. F. (2019). Skills required for woodwork technology capacity building as perceived by technical educators in Nigeria south-west colleges of education. *Journal of Emerging Trends in Educational Research and Policy Studies, 17*(6), 395 – 398.

Adeagbo, I. F., & Ayano, A. S. (2019). Assessment of woodwork technology skills possessed by oyo state technical colleges graduates in response to 2030 education agenda for lifelong learning. *Southwest Journal of Teacher Education, 10*(1), 27 - 33.

Alyoubi, A. A. (2015). E-commerce in developing countries and how to develop them during the introduction of modern systems. *Procedia Computer Science, 65*, 479-483

Ayoola, A. A., Akinlabi, W. I., & Adeagbo, I. F. (2023). Assessment of emerging technologies on building/woodwork technology students' academic performance in Tai Solarin University of Education, Ijebu- Ode, Ogun State. *Nigerian Online Journal of Educational Sciences and Technology, 5*(1), 234 – 243.

Brandes, D., & Zobrist, L. (2017). What key competencies are needed in the digital age? The impact of automation on employees, companies and education. Deloitte AG. www2deloitte .com/ content/ dam/ Deloitte/ ch/ Documents/ innovation/ ch-en – innovatio automation -competencies .pdf

Bukht, R., & Heeks, R. (2017). Defining, conceptualizing and measuring the digital economy, development informatics working paper 68. University of Manchester, UK

Efanimjor, I., & Okolocha, C. C. (2020). Assessment of the adequacy of curriculum content of business education for skills acquisition in colleges of education in Edo and Delta States. *Journal of Research & Method in Education, 10*(1), 01-12.

Ferrari, A. (2013). DIGCOMP: A framework for developing and understanding digital competence in Europe. Institute for Prospective Technological Studies. http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=6359.

International Telecommunication Union. (ITU, 2020). Digital skills toolkit. https:// www .itu .int/ en/ ITU /Digital -Inclusion/ Documents/ ITU %20Digital %20Skills %20Toolkit .pdf

Ndubuisi, I. S., Ezeani, C. F., & Ile, C. M. (2022). Integrating digital skills in business education curriculum in tertiary institutions for digital economy development. *Nigerian Journal of Business Education, 9*(1), 107 – 117.

OECD (2015). OECD digital economy outlook. Published July 15. http://www.oecd ilibrary.org/science-and-technology/oecd-digital-economy-outlook- 2015_9789264232440-en

Oguejiofor, C. S. (2020). Integrating e-commerce in business education curriculum for global competitiveness. *Nigerian Journal of Business Education,* 7(1), 27-34.

Okoye, A. C. (2017). ICT skills required of business education graduates for effective entrepreneurship practice in Anambra State. *Nigerian Journal of Business Education, 4*(1), 334-345

UNESCO Institute of Statistics (2018). A global framework of reference on digital literacy Skills for indicator 4.4.2. Information Paper No. 51, UIS/2018/ICT/IP/51

World Economic Forum (2018). Digital skills among population report. https:// tcdata360.worldbank .org/ indicators/ h945a9708?country = BRA & indicator = 41400 & viz = line _chart & years = 2017 ,2019

EFFECT OF AI-ENHANCED HYBRID WOOD FINISHING TECHNIQUES ON THE APPEARANCE AND DURABILITY OF LECTURE THEATRE FURNITURE IN BENUE STATE TERTIARY INSTITUTIONS

ALAKI Sunday 08077729926 alakisunday1971@gmail.com
&
AGISHI Solomon Kwaghkur 08036550570 agish@bsum.ed.ng
Department of Industrial technology, Fr. Moses Orshio Adasu University, Makurdi

Abstract

The study investigates the effect of AI-enhanced hybrid wood finishing techniques on the appearance and durability of lecture theatre furniture in tertiary institutions in Benue State, Nigeria. Two specific objectives with corresponding research questions guided the study and two hypotheses were formulated to be tested at 0.05 level of significant. The study adopted a quasi-experimental design. The population of the study comprises 2,567 Students and lecturers from tertiary institutions in Benue State, Nigeria. The sample size of 100 Students and lecturers from tertiary institutions obtained using purposive sampling technique. The instrumenst used for data collection were multiple instruments. The instruments were validated by experts and reliability was established Using Cronbach Alpha method which yielded a coefficient of 0.79. Mean and standard deviation were used to analyse the research questions and Analysis of Covariance (ANCOVA) was used to test the research hypotheses at 0.05 level of significant. Findings suggest that application of AI-enhanced hybrid wood finishing techniques significantly improve the appearance and durability of lecture theatre furniture in tertiary institutions. Based on the findings, recommendations were made that tertiary institutions should consider adopting AI-enhanced hybrid wood finishing techniques to improve furniture appearance and durability.
Keywords: AI-enhanced hybrid wood finishing techniques, Appearance, Durability, Lecture theatre furniture, Tertiary institutions

Introduction

The integration of Artificial Intelligence (AI) in wood finishing techniques has revolutionized the furniture industry (Kim, 2020). AI-enhanced hybrid wood finishing techniques can improve the appearance and durability of wood products by optimizing the finishing process and reducing defects. These techniques can also enhance the sustainability of wood products by reducing waste and improving the efficiency of the finishing process (Wang, 2020).

Traditional wood quality control methods are manual processes have long been the norm. These processes involve visually inspecting and physically testing the wood to ensure its quality meets the industry standards (Lee, 2019). However, traditional methods often face challenges and limitations, such as subjectivity in assessments and time-consuming processes. After understanding the intricacies of manual wood quality control processes, it is essential to recognize the challenges and limitations they pose. Traditional methods heavily rely on human inspection, making them subjective and prone to errors. Identifying wood defects accurately is a complex task that requires trained expertise and extensive experience. Moreover, the human eye can easily miss minor defects that may compromise the final product's quality. This is where the integration of artificial intelligence techniques, such as neural networks, becomes crucial.

The integration of Artificial Intelligence (AI) in various industries has revolutionized traditional practices, enhancing efficiency, quality, and innovation. One such industry is

wood finishing, where AI-enhanced hybrid techniques are being explored for their potential to improve both the appearance and durability of wood products. Lecture theatre furniture, particularly in tertiary institutions, plays a crucial role in creating an optimal learning environment. The quality and aesthetic appeal of this furniture can significantly impact student engagement and academic performance (Zhang, 2020).

In Benue State tertiary institutions, like many others, the demand for high-quality furniture that can withstand heavy use is growing. Traditional wood finishing techniques, while effective, often face challenges such as inconsistency, human error, and limited durability. AI-enhanced hybrid wood finishing techniques offer a promising solution to these challenges by combining advanced algorithms and machine learning with traditional craftsmanship.

The aesthetic appeal and durability of lecture theatre furniture are crucial factors in creating a conducive learning environment in tertiary institutions (Abdulrahman, 2018). In Benue State, Nigeria, the furniture in lecture theatres plays a significant role in enhancing the learning experience of students. However, the durability and aesthetic appeal of these furniture pieces can be compromised due to various factors, including the type of materials used and the finishing techniques employed (Adebayo, 2019).

Studies have shown that AI-enhanced hybrid wood finishing techniques can significantly improve the aesthetic appeal of wood products. For instance, Wang (2020) found that AI-optimized wood finishing techniques can produce high-quality finishes with improved color consistency and texture. Similarly, Chen (2019) reported that AI-enhanced hybrid wood finishing techniques can enhance the visual appeal of wood products by reducing defects and improving the overall finish.

AI-driven systems ensure consistent application of finishes, reducing human error and variability in the final product (Kumar *et al.,* 2020). This precision contributes to a more uniform and professional appearance of the furniture. AI can analyze wood grain patterns and suggest optimal finishing techniques to enhance the natural beauty of the wood, bringing out its inherent colors and textures (Li *et al.,* 2021). Advanced finishing techniques facilitated by AI can achieve high-gloss finishes or matte effects, depending on the desired aesthetic, thereby improving the overall visual appeal of the furniture (Wang *et al.,* 2019).

In addition to aesthetic appeal, AI-enhanced hybrid wood finishing techniques have also been shown to improve the durability of wood products. According to Li (2018), AI-optimized wood finishing techniques can improve the scratch resistance and wear resistance of wood products, thereby extending their lifespan. Furthermore, Zhang (2020) found that AI-enhanced hybrid wood finishing techniques can improve the moisture resistance of wood products, reducing the risk of warping and cracking.

The impact of AI-enhanced hybrid wood finishing techniques on the aesthetic appeal and durability of lecture theatre furniture in tertiary institutions in Benue State, Nigeria, may be influenced by various contextual factors. For instance, the type of wood used, the design of the furniture, and the environmental conditions in the lecture theatre can all impact the performance of the furniture (Abdulrahman, 2018). Therefore, it is essential to consider these factors when assessing the impact of AI-enhanced hybrid wood finishing techniques on lecture theatre furniture.

AI technology has been increasingly applied in wood processing and finishing to improve precision, consistency, and quality. According to Zhang et al. (2022), AI-driven systems can analyze wood grain patterns, detect defects, and optimize finishing processes, resulting in enhanced aesthetic appeal and durability. These advancements are particularly relevant for educational institutions, where furniture must meet high standards of quality and functionality.

Research has shown that AI-enhanced hybrid wood finishing techniques can significantly improve the quality and durability of wood products. According to Wang et al. (2019), AI-driven systems can analyze wood grain patterns, detect defects, and optimize finishing processes, resulting in enhanced aesthetic appeal and durability. These techniques have the potential to transform the wood finishing industry by improving efficiency, consistency, and quality.

Lecture theatre furniture is more than just a functional element; it contributes to the overall learning environment. High-quality furniture can enhance student comfort, engagement, and focus, ultimately supporting academic performance (Hwang *et al.,* 2018). In Benue State tertiary institutions, the condition and quality of lecture theatre furniture can vary, with many institutions facing challenges related to durability and maintenance.

While there is growing interest in AI-enhanced hybrid wood finishing techniques, there is limited research on their specific application in tertiary institutions, particularly in the context of Benue State. This study aims to fill this gap by exploring the effects of these techniques on the appearance and durability of lecture theatre furniture in this region.

Statement of the Problem

The quality and durability of lecture theatre furniture in Benue State tertiary institutions have been a persistent concern, impacting the learning environment and overall academic experience. Traditional wood finishing techniques, while widely used, often result in inconsistencies, defects, and limited durability, leading to frequent maintenance and replacement needs. This not only increases costs but also disrupts the learning process. Lecture theatre furniture in Benue State tertiary institutions often suffers from wear and tear, reducing its lifespan and increasing maintenance costs. Traditional wood finishing techniques can result in inconsistencies in appearance and quality, affecting the overall aesthetic appeal of the furniture. AI-enhanced hybrid wood finishing techniques may offer improved appearance, increased durability, and reduced maintenance costs, but these benefits need to be investigated in the specific context of Benue State tertiary institutions. The integration of Artificial Intelligence (AI) in wood finishing offers a potential solution to these challenges. However, there is limited research on the specific effects of AI-enhanced hybrid wood finishing techniques on the appearance and durability of lecture theatre furniture, particularly in the context of Benue State tertiary institutions. This study aims to investigate the effects of AI-enhanced hybrid wood finishing techniques on the appearance and durability of lecture theatre furniture in Benue State tertiary institutions, with a view to identifying potential benefits and challenges of adopting this technology.

Objectives of the Study

The main aim of this study was to investigate effect of AI-enhanced hybrid wood finishing techniques on the appearance and durability of lecture theatre furniture in tertiary institutions in Benue State tertiary institutions.

Specifically, the study sought to achieve the following objectives:

i. Evaluate the effect of AI-enhanced hybrid wood finishing techniques on the appearance of lecture theatre furniture in Benue State tertiary institutions.
ii. Assess the effect of AI-enhanced hybrid wood finishing techniques on the durability of lecture theatre furniture in Benue State tertiary institutions.

Research Questions

Two research questions guided the study the study:

i. What is the effect of AI-enhanced hybrid wood finishing techniques on the appearance of lecture theatre furniture in Benue State tertiary institutions?
ii. To what extent do AI-enhanced hybrid wood finishing techniques affect the durability of lecture theatre furniture in Benue State tertiary institutions?

Research Hypotheses

The following research hypotheses were formulated and tested at 0.05 level of significant:

i. There is no significant difference in the appearance of lecture theatre furniture treated with AI-enhanced hybrid wood finishing techniques compared to those treated with traditional methods.
ii. There is no significant difference in the durability of lecture theatre furniture treated with AI-enhanced hybrid wood finishing techniques compared to those treated with traditional methods.

Methodology

The study adopted quasi-experimental, pretest, post-test non-equivalent control group research design according to Abonyi, et al (2022), quasi-experiment is an experiment where it is not possible to randomly assign subjects to experimental and control group. The study made use of intact classes in order not to disrupt normalcy in setting. The design can be illustrated thus:

Q1 X Q2
Q1 C Q2
Where
Q1 represents pretest of experimental and control group
Q2 represents post-test of experimental and control group
X represents treatment of experiment (AI) for the experimental group
C represents the conventional method for the control group

The area of the study was Benue State, Nigeria. The population of the study comprises 2,567 Students and lecturers from tertiary institutions in Benue State, Nigeria. The sample size of 100 Students and lecturers from tertiary institutions obtained using purposive sampling technique. The instruments used for data collection were Observation Checklist (OC), Standardized Rating Scales (SRS), Durability Testing Protocols (DTP), Photographic Documentation (PD), Material Testing Instruments (MTI). Under the observation check list, there were systematically record observations about the appearance and durability of the furniture before and after the application of AI-enhanced hybrid wood finishing techniques. The content includes criteria such as surface smoothness, colour consistency, resistance to scratches, and overall aesthetic appeal. Similarly, under the standardized rating scales, quantify subjective assessments of the furniture's appearance and durability was carried out. The content includes developing Likert-type scales (e.g., 1-5) to rate attributes like finish quality, durability, and visual appeal. The third instrument which is Durability Testing Protocols (DTP) was to objectively measure the durability of the furniture under controlled conditions. The content includes tests for resistance to wear, moisture, heat, and chemicals. The fourth instrument which is Photographic Documentation (PD) was to visually record the condition of the furniture before and after treatment. The content includes taking high-quality photos from multiple angles under controlled lighting conditions. The fifth instrument which is Material Testing Instruments (MTI) was to measure physical properties of the wood and finish (e.g., hardness, adhesion, gloss). The content here include: using instruments like a gloss meter, adhesion tester, or scratch tester.

Lastly. AI-Based Assessment Tools (ABAT) was used analyze the finish quality and detect defects using AI algorithms. The content includes using image processing software to evaluate surface imperfections, colour uniformity, and other attributes. The implementation of the instruments was the administration of pre-test and post-test. In the pre-test, baseline measurements were conducted before applying the AI-enhanced finishing techniques. The scores were computed. In post-test, repeat measurements were made after the treatment to assess changes. The scores were also computed. By combining these instruments, the study

can provide a comprehensive evaluation of the effect of AI-enhanced hybrid wood finishing techniques on the appearance durability of lecture theatre furniture. Cronbach Alpha reliability coefficient method was considered suitable due to its flexibility for use. Reliability coefficient for each of the instruments as overall reliability index of 0.85 was obtained. The descriptive statistics of Mean Score (x) and Standard Deviation (sd) were used to answer the research questions while the hypotheses were analyzed using Analysis of Covariance (ANCOVA). The decision for accepting or rejecting the null hypotheses was based on comparison of calculated F-value and critical F value. Thus, if calculated F value is less than critical value, the hypothesis will be rejected and vice versa for it to be rejected.

Presentation of Results

Research Question 1: What is the effect of AI-enhanced hybrid wood finishing techniques on the appearance of lecture theatre furniture in Benue State tertiary institutions?

Table 1: Mean and Standard Deviation of the effect of AI-enhanced hybrid wood finishing techniques on the appearance of lecture theatre furniture

Group	**N**	$\bar{X}$ Pre-test	$\bar{X}$ Post-test	Mean Gain	**Standard Deviation**	**P.Value**	**Decision**
Experimental	55	5.70	12.16	6.46	1.24	0.001	Positive Effect
Control	45	5.67	6.47	0.80	0.37		

Source: field work, 2025

Table 1 shows that the Pre-test, AI-enhanced hybrid wood finishing techniques resulted in a significant improvement in surface quality, with reduced imperfections and defects, experimental group had a mean score of 5.70 with a standard deviation of 1.24 while the control group had 5.67 as their mean score with a standard deviation of 0.37. In the Post-test, the lecture theatre furniture in the experimental group had a mean score of 12.16 with a standard deviation of 1.24 while the lecture theatre furniture in the control group had 6.47 as mean score with a standard deviation of 0.80. From the Pre-test and Post-test scores, the effect for the experimental group was found to be 6.46 while the effecte for the control group was 0.80. The decision rule is positive effect. This indicates that AI-enhanced finishes demonstrated better colour consistency and uniformity, contributing to a more aesthetically pleasing appearance.

Research Question 2

To what extent do AI-enhanced hybrid wood finishing techniques affect the durability of lecture theatre furniture in Benue State tertiary institutions?

Table 2: Mean and Standard Deviation of effect of AI-enhanced hybrid wood finishing techniques on the durability of lecture theatre furniture

Group	**N**	$\bar{X}$ Pre-test	$\bar{X}$ Post-test	Mean Gain	**Standard Deviation**	**P.Value**	**Decision**
Experimental	55	6.26	13.80	7.54	0.04	0.002	Positive Effect
Control	45	6.24	7.68	1.44	0.14		

Source: field work, 2025

From Table 2, it can be seen that in Pretest, the experimental group had a mean score of 6.26 with a standard deviation of 0.04, while the control group had a mean score of 6.24 with a standard deviation of 0.14. The Table also shows that in the post-test, the experimental group had a mean score of 13.80 with a standard deviation of 0.04, while the control group had a mean score of 7.68 with the standard deviation of 0.14 From the pre-test and post-test scores, the effect for the experimental group was found to be 7.54 while the effect for the control group was 1.44. This means that AI-enhanced finishes demonstrated improved resistance to wear and tear, including scratches, marks, and fading.

Research Hypothesis 1: There is no significant difference in the appearance of lecture theatre furniture treated with AI-enhanced hybrid wood finishing techniques compared to those treated with traditional methods.

TABLE 3: Summary of Analysis of Covariance (ANCOVA) of Experimental and Control Group on effect of AI-enhanced hybrid wood finishing techniques on the appearance of lecture theatre furniture

Source of Variance	Sum of Squares	Df	Mean Square	F	P
Corrected Mode	949.735	2	474.867	157.756	.00
Intercept	2146.142	1	2146.142	712.973	.00
Pretest	54.636	1	54.636	18.151	.00
Group of Furniture (Control and Exp.)	891.995	1	891.995	296.331	.00
Error	698.350	232	3.010		
Total	23095.000	235			
Corrected Total	**1648.085**	**234**			

Source: field work, 2025

Table 3 showed ANCOVA analysis of the data collected from the post-test scores of the appearance of lecture theatre furniture. From the analysis reading the row heading Group, Df1, F= 296.331 and P =.00, that is, $p<0.05$. Hence, the null hypothesis is rejected. This means that the AI-enhanced finishes has higher on appearance-related attributes, such as surface quality, colour consistency, and gloss retention. This further indicates that the AI-enhanced finishes received higher overall satisfaction ratings from users. This means that AI-enhanced finishes demonstrated improved colour consistency and uniformity.

Research Hypothesis 2: AI-enhanced hybrid wood finishing techniques do not significantly improve the durability of lecture theatre furniture in Benue State tertiary institutions.

TABLE 4: Summary of Analysis of Covariance (ANCOVA) of effect of AI-enhanced hybrid wood finishing techniques on the durability of lecture theatre furniture

Source of Variance	Sum of Squares	Df	Mean Square	F	P
Corrected Mode	263.528	2	131.764	117.188	.00
Intercept	601.275	1	601.275	534.763	.00
Pretest	1.008	1	1.008	0.897	.35
Group of Furniture (Control and Exp.)	262.204	1	262.204	233.199	.00
Error	260.855	232	1.124		
Total	23133.000	235			
Corrected Total	**524.383**	**234**			

Source: field work, 2025

Table 4 showed ANCOVA analysis of the data collected from the posttest scores of lecture theatre furniture and those which were not treated with AI-enhanced hybrid wood finishing techniques. From the analysis reading the row heading Group, Df=1, F=233.199 and P value is 0.00, $p<0.05$. Hence, the null hypothesis is rejected. This means that there is a statistically significant difference in the mean scores of lecture theatre furniture and those which were not treated with AI-enhanced hybrid wood finishing techniques. This further indicated that the AI-enhanced finishes demonstrated improved resistance to wear and tear, including scratches, marks, and fading. This means that the AI-enhanced finishes showed better durability and longevity compared to traditional finishes.

Discussion

The study investigated the effect of AI-enhanced hybrid wood finishing techniques on the appearance durability of lecture theatre furniture. The findings are based on a comprehensive analysis of data collected using observation checklists, standard rating scales, durability testing protocols, photographic documentation, material testing instruments, and AI-based assessment tools. The study's findings suggest that AI-enhanced

hybrid wood finishing techniques significantly improve the appearance durability of lecture theatre furniture. The results demonstrate improved surface quality, colour consistency, gloss retention, and resistance to scratches and marks. The positive user perception and improved durability confirm the effectiveness of AI-enhanced finishes in enhancing the appearance of lecture theatre furniture.

Hypothesis one revealed that AI-enhanced hybrid wood finishing techniques has shown promising results in improving the appearance of lecture theatre furniture. The finding is in line with that of Zhang et al. (2022) who reported that these techniques combine traditional wood finishing methods with advanced AI-driven processes, resulting in enhanced aesthetic appeal and quality. The finding also conforms to that of Kumar *et al.,* (2020) who captured that AI-enhanced hybrid wood finishing techniques can significantly improve the surface quality of wood, reducing imperfections and enhancing the overall appearance of the furniture. The finding agrees with that of Li *et al.,* (2021) who were on the view that, AI systems can analyze wood grain patterns and optimize finishing techniques to achieve consistent color and texture, resulting in a more visually appealing final product.

Lastly, hypothesis two indicated that, there is significant effect of adopting AI-enhanced hybrid wood finishing techniques on production of lecture theatre furniture. The finding of this study collaborates with that of Zhang et al. (2022) who were on the opinion that AI-enhanced hybrid wood finishing techniques has demonstrated significant improvements in the durability of lecture theatre furniture. According to them, these techniques leverage advanced AI algorithms and machine learning to optimize wood finishing processes, resulting in enhanced durability and resistance to wear and tear. The finding also conforms to that of Wang *et al.,* (2019) who were on the view that AI-enhanced hybrid wood finishing techniques can significantly improve the scratch resistance of wood surfaces, reducing the risk of damage and extending the lifespan of the furniture. Similarly, the finding corresponds to that of Li *et al.,* (2021) who reported that AI-optimized finishing techniques can also improve the moisture resistance of wood, reducing the risk of warping, cracking, or rotting.

Conclusion

The integration of AI-enhanced hybrid wood finishing techniques in the production of lecture theatre furniture in Benue State tertiary institutions has shown promising results in improving both the appearance and durability of the furniture. By leveraging advanced algorithms and machine learning, these techniques can optimize wood finishing processes, resulting in enhanced aesthetic appeal, improved surface quality, and increased resistance to wear and tear.

The benefits of AI-enhanced hybrid wood finishing techniques are multifaceted. They can improve the color consistency and texture of wood, detect and correct defects, and enhance the scratch and moisture resistance of the furniture. These advancements can lead to extended lifespans, reduced maintenance costs, and improved overall quality of the furniture.

In the context of Benue State tertiary institutions, the adoption of AI-enhanced hybrid wood finishing techniques can have a significant impact on the learning environment. By providing students with high-quality, durable, and aesthetically pleasing furniture, institutions can create a more conducive and engaging learning environment that supports academic excellence.

Overall, the effects of AI-enhanced hybrid wood finishing techniques on the appearance and durability of lecture theatre furniture in Benue State tertiary institutions are substantial. As the technology continues to evolve, it is likely that we will see even more innovative applications of AI in wood finishing, leading to further improvements in the quality and sustainability of furniture production.

Recommendations

Based on the findings of this research, the following recommendations are made:

1. Institutions should consider investing in AI-enhanced hybrid wood finishing technology to improve the quality and durability of lecture theatre furniture.
2. Institutions should provide training and capacity-building programs for furniture makers and maintenance staff to ensure they are equipped to work with AI-enhanced hybrid wood finishing techniques.
3. Institutions should establish quality control measures to ensure that AI-enhanced hybrid wood finishing techniques are applied consistently and effectively.
4. Institutions should develop maintenance and upkeep plans to ensure that lecture theatre furniture treated with AI-enhanced hybrid wood finishing techniques remains in good condition.
5. Institutions should collaborate with industry partners to stay up-to-date with the latest developments in AI-enhanced hybrid wood finishing techniques and to identify opportunities for innovation and improvement.

References

Abdulrahman, A. (2018). Furniture design and learning environment: A study of universities in Nigeria. *Journal of Interior Design*, 43(2), 35-47.

Abonyi, O. S, Okereke, S. C., Omebe, C. A., Anuguwo, C. & Nnachi, F. (2022). Methodoloical approaches in quasi-experimental studies: *Applications in Foundational Research, Nigerian Educational Research Review,* 20(3), 145-165

Adebayo, A. (2019). Wood finishing techniques and durability: A review. *Journal of Wood Science*, 55(3), 279-290.

Chen, L. (2019). AI-enhanced hybrid wood finishing techniques: A study of aesthetic appeal. *Journal of Furniture Design*, 42(1), 19-31.

Chen, Y., Zhang, J., & Liu, X. (2021). Customization of wood furniture finishes using AI-driven design systems. *Journal of Wood Science*, 67(1), 1-12.

Hwang, G. J., Lai, C. L., & Wang, S. Y. (2018). Impacts of furniture design on learning environments: A systematic review. *Educational Technology & Society*, 21(2), 14-27.

Kim, J. (2020). Artificial intelligence in woodworking: A review. *Journal of Wood Science*, 56(1), 1-12.

Kumar, P., Singh, R., & Kumar, A. (2020). Precision wood finishing using machine learning algorithms. *Journal of Manufacturing Processes*, 56, 340-349.

Lee, S. (2019). Hybrid wood finishing techniques: A study of aesthetic appeal and durability. *Journal of Furniture Design*, 42(1), 19-31.

Li, M. (2018). AI-optimized wood finishing techniques: A study of scratch resistance. *Journal of Materials Science*, 53(11), 8442-8453.

Li, M., Liu, Y., & Chen, L. (2021). AI-based wood grain pattern analysis for enhanced finishing techniques. *Wood Science and Technology*, 55(3), 637-651.

Wang, Q., Li, J., & Zhang, Y. (2019). Advanced wood finishing techniques using AI and robotics. *Journal of Cleaner Production*, 235, 1220-1228.

Wang, Y. (2020). Sustainable wood finishing: A review of AI-enhanced techniques. *Journal of Cleaner Production*, 286, 120926.

Zhang, J. (2020). Moisture resistance of wood products: A study of AI-enhanced hybrid wood finishing techniques. *Journal of Wood Science*, 56(2), 149-160.

Zhang, W., Chen, H., & Li, Z. (2022). Hybrid wood finishing techniques enhanced by AI: A review. *Forests*, 13(8), 1245.

HARNESSING AI-DRIVEN DIGITAL SKILLS IN BUILDING AND WOODWORK TECHNOLOGY EDUCATION FOR TVET GRADUATES: A PATHWAY TO ECONOMIC DIVERSIFICATION AND SUSTAINABLE INDUSTRIAL GROWTH IN EMERGING ECONOMIES

[1]Okeowo Rebecca Oyenike, [2]Ayeoribe Toyin, S., [1]Okeowo Odunayo Sunday & [1]Adewuyi, Babajide Adetunji
[1]Dept. of Technology Education, Lagos State University of Education, Oto/Ijanikin, Lagos State
[2]Dept. of Woodwork Technology Education, Federal College of Education (Tech.), Akoka, Yaba Lagos.

okeowosunday@gmail.com / tayeoribe@gmail.com

Abstract

This study investigates how integrating AI-driven digital skills into Building and Woodwork Technology Education can reshape Technical and Vocational Education and Training (TVET) in emerging economies. Focusing on Lagos State, Nigeria, the research draws insights from 66 stakeholders across four tertiary institutions, including lecturers, students, and industry professionals. The findings highlight a strong shared belief in AI's ability to boost graduates' technical competence, job readiness, and capacity for innovation within the construction and woodwork sectors. Despite these promising prospects, the journey toward full AI adoption faces real challenges: limited infrastructure, inadequate funding, and a shortage of trained educators. To address these gaps, the study recommends strategic reforms such as modernizing curricula, fostering closer ties between academia and industry, and investing in AI-enabled training environments. Ultimately, the research emphasizes that with a unified and deliberate approach, AI can become a powerful catalyst for economic diversification and sustainable industrial development in emerging regions.

Keywords: AI-driven digital skills, Building and Woodwork Technology, Economic diversification, Sustainable industrial growth, Emerging economies, Digital fabrication, Smart construction.

Introduction

Emerging economies are at a turning point. Traditionally reliant on resource-based sectors like oil, mining, and agriculture, these nations often face economic instability due to fluctuating global markets, weak infrastructure, and limited industrial capacity. However, the global transition to digital and green economies presents an opportunity, particularly for countries with large, youthful populations, to rethink their development strategies (Tran,et al 2020). Central to this shift is the integration of Artificial Intelligence (AI)-driven digital skills into vocational education and training (TVET), especially in fields such as building and woodwork technology.

The convergence of AI with technical education is more than a technological upgrade. It is a transformative strategy for economic diversification. Abdullah, Hajamydeen, & Johar, (2025) stated that by equipping TVET graduates with competencies in AI-enhanced design, digital fabrication, smart construction, and sustainable production techniques, emerging economies can move beyond extractive industries into value-added sectors like modular housing, eco-friendly furniture manufacturing, and digital construction services. This

transition not only generates high-quality jobs but also catalyses local innovation, strengthens industrial competitiveness, and promotes resilience against global economic shocks.

In many developing nations, construction and woodworking are deeply rooted in local craftsmanship and informal economies (Yadav, Tripathi, & Tripathi, 2022). While these sectors have cultural and historical significance, they have been slow to scale, modernize, or compete globally. AI changes that equation. For example, generative design tools allow builders to optimize the use of local materials, reducing waste and improving cost-efficiency. Predictive analytics can streamline construction workflows, while CNC machines and smart design platforms can upgrade traditional woodcraft into precision manufacturing (Yin, et. al 2023). These capabilities open new doors for export-oriented growth. Smart furniture embedded with IoT features or modular structures tailored for climate-resilient housing are fast-growing global markets. With AI-trained TVET graduates, emerging economies can tap into these opportunities. This transformation aligns well with national development strategies such as Nigeria's Economic Recovery and Growth Plan (ERGP), which emphasizes innovation, job creation, and industrial expansion (Anam, et. al 2024)

Despite the potential, the path to integrating AI into TVET is filled with structural challenges. In many TVET institutions across Africa, Asia, and parts of Latin America, basic infrastructure, such as electricity, reliable internet, and up-to-date equipment, is lacking (Charles, et al 2023). AI-powered tools like CNC routers, 3D printers, and simulation software are either unavailable or unaffordable. As a result, students in underserved regions are excluded from the benefits of digital learning and industry-ready training. Addressing this digital divide requires a combination of targeted investments and policy innovation. Governments must prioritize infrastructure development in education budgets, while forming partnerships with tech companies to make tools and platforms more accessible. Low-bandwidth AI applications, mobile learning systems, and shared maker spaces are practical solutions for resource-constrained environments (Agbeyangi, & Suleman, 2024). Open-source platforms can also offer affordable alternatives to proprietary software, democratizing access to digital learning.

Furthermore, educators must be empowered to lead this transformation. Many instructors in TVET systems have limited exposure to AI tools or digital pedagogy. Professional development programs should include hands-on AI training, modern instructional strategies, and real-world project-based learning. Countries like Kenya and Singapore have shown how continuous upskilling, supported by industry partnerships, can modernize vocational training (Kebede, Asgedom, & Asfaw, 2024). When educators are equipped and confident, they can better inspire and prepare students to become innovators and entrepreneurs. Sustainability is now a non-negotiable aspect of global industrial development. As the world races to meet climate goals, industries must reduce emissions, manage waste, and embrace circular economy practices. TVET institutions have a crucial role in preparing graduates with the "green skills" necessary to build in ways that are both efficient and environmentally responsible.

AI can accelerate the acquisition of these green skills. For instance, AI-powered design software can simulate energy-efficient buildings before they are constructed (Yitmen, et.al 2025). Machine learning tools can optimize material use in woodwork to minimize waste. Smart sensors can help monitor energy consumption in real time, reinforcing eco-conscious behaviours during training. Integrating these tools into building and woodwork curricula ensures that students not only learn how to use advanced technologies but also understand their impact on sustainability.

Unfortunately, green AI technologies are often inaccessible to the very institutions that need them most. Rural or low-income TVET centers lack renewable-powered labs or updated

curricula that reflect environmental priorities. Moreover, indigenous sustainable practices—like earth-based construction or traditional timber preservation—are frequently overlooked in modern training programs (Morel, et.al 2021). Yet these local methods, if enhanced by digital tools, could become globally competitive. To overcome these challenges, national education policies must align with sustainability goals and industrial growth strategies. International partnerships, regional innovation hubs, and context-specific curricula are critical to ensuring inclusive and locally relevant transformation.

AI is not just about algorithms and automation; it's about empowering people. For emerging economies, the real value of integrating AI into technical education lies in cultivating a skilled workforce capable of building industries from the ground up (Ghosh, & Ravichandran, 2024). TVET graduates trained in digital fabrication, smart construction, and eco-conscious design can launch startups, attract investment, and solve local challenges with global tools. Moreover, these skills enable nations to reduce reliance on foreign expertise, enhance local supply chains, and take advantage of regional trade agreements such as the African Continental Free Trade Area (AfCFTA). The knock-on effects are substantial: increased exports, new industrial clusters, greater job creation, and more resilient economies.

Realizing this vision will require a deliberate, collaborative effort across sectors. Policymakers must prioritize education funding, develop incentives for private sector collaboration, and adopt adaptive policy frameworks that respond to both local realities and global trends. Educators must embrace continuous learning and innovation, while industry must play an active role in shaping curricula and offering real-world learning opportunities. Above all, governments and stakeholders must see AI not as a luxury but as a necessary investment in the future. AI-enhanced vocational training offers a powerful vehicle for inclusive, sustainable, and innovation-led development. By embedding digital skills into building and woodwork technology education, emerging economies can transform traditional trades into engines of industrial growth and chart a new path toward economic resilience and prosperity (Esposito, & Kapoor, 2022).

Statement of the Problem

In many emerging economies, technical and vocational education in building and woodwork technology has long relied on traditional teaching methods—chalkboard lessons, manual training, and time-tested craftsmanship. These methods have shaped generations of skilled workers. Yet, as industries rapidly adopt digital technologies, automation, and AI, the skills taught in many TVET institutions no longer align with what today's job market demands. Graduates often leave with solid hands-on abilities but lack the digital competencies needed to thrive in modern, tech-driven workplaces.

This divide is becoming more visible as construction and woodwork industries evolve, integrating smart design software, automated machinery, and data-driven systems to boost efficiency and sustainability. Unfortunately, many TVET programs have been slow to catch up. Infrastructure remains outdated, instructors often lack exposure to AI tools, and there is little support in the form of clear policy or industry collaboration. As a result, students are left behind, not because they lack talent, but because they aren't given the tools to compete in the digital age.

This growing gap between training and technology doesn't just affect individual careers; it holds back entire economies. Countries striving to move beyond dependence on oil or agriculture and build more resilient, knowledge-based industries are limited by a workforce that hasn't been prepared for this transition. Without deliberate action to modernize training, support educators, and build stronger links between schools and industry, TVET systems will continue to fall short. Addressing this gap is not just a matter of education reform, it's a crucial step toward empowering young people, transforming local industries, and opening

new pathways to sustainable economic growth. AI-driven digital skills could be the bridge between traditional trades and future-ready industries if the right strategies are put in place now.

Purpose of the Study

1. To investigate the effect of integrating AI-driven digital skills into building and woodwork technology education on improving the job readiness and technical competencies of TVET graduates in emerging economies.

2. To identify the challenges and opportunities associated with incorporating AI technologies into TVET curricula and training processes for building and woodwork trades.
3. To develop strategic recommendations for policymakers, educators, and industry stakeholders to effectively harness AI-driven digital skills in TVET for sustainable industrial growth and economic diversification.

Research Questions

1. How does the integration of AI-driven digital skills in building and woodwork technology education affect the job readiness and technical competencies of TVET graduates in emerging economies?
2. What are the key challenges and opportunities faced by TVET institutions in incorporating AI technologies into their building and woodwork curricula and training practices?
3. What strategies can policymakers, educators, and industry stakeholders adopt to effectively leverage AI-driven digital skills for promoting sustainable industrial growth and economic diversification through TVET programmes?

Hypotheses

1. There is no significant difference between the integration of AI-driven digital skills in building and woodwork technology education and the job readiness or technical competencies of TVET graduates in emerging economies.
2. There are no significant challenges or opportunities affecting the incorporation of AI technologies into building and woodwork curricula and training practices in TVET institutions.
3. There is no significant effect of strategies implemented by policymakers, educators, and industry stakeholders on leveraging AI-driven digital skills for sustainable industrial growth and economic diversification through TVET programmes.

Methodology

This study adopted a descriptive survey research design to gain meaningful insights from stakeholders directly involved in Building and Woodwork Technology Education. The goal was to understand their perspectives on the integration of AI-driven digital skills into teaching and learning. The research focused on four prominent tertiary institutions in Lagos State, University of Lagos (UNILAG), Lagos State University of Education (LASUED), Yaba College of Technology (YABATECH), and the Federal College of Education (Technical), Akoka (FCE Tech.). A total of 66 participants were purposively selected, comprising 20 lecturers, 16 industry experts, and 30 students, all of whom are active contributors to the field either academically or professionally.

To collect data, the researchers developed a well-structured instrument titled *"AI Integration and Digital Skill Development in Building/Woodwork Technology Education Questionnaire (AIDSBWTEQ)"*. The questionnaire was organized into three key sections: respondent demographics, perceptions of AI-driven skills for job readiness, and challenges with suggested strategies for implementation. Responses were gathered using a 5-point Likert scale ranging from *Strongly Agree (5)* to *Strongly Disagree (1)*. For content validation, three

experienced scholars, two from UNILAG and one from LASUED, carefully reviewed the instrument to ensure its relevance, clarity, and alignment with the study's objectives.
To confirm the instrument's reliability, a pilot study was carried out using a sample of 12 respondents not included in the main study. The results produced a Cronbach's Alpha coefficient of 0.83, reflecting strong internal consistency and reliability of the questionnaire. Following this, the main data collection was conducted through a combination of physical distribution and electronic means to ensure wide reach and ease of access for all participants. Data analysis was conducted using SPSS version 26. Descriptive statistics, namely mean and standard deviation, were used to interpret the general trends and perceptions of respondents. To test for significant differences among the various respondent groups (lecturers, industry experts, and students), the study employed Analysis of Variance (ANOVA) at a 0.05 level of significance. The findings from this analysis not only informed the interpretation of results but also laid the groundwork for strategic recommendations aimed at improving AI integration in technical education and strengthening job readiness in the building and woodwork sector.

Results

Table 1: AI-Driven Skills and Graduate Competence

S/N	Item Statement	L (Mean)	L (SD)	IE (Mean)	IE (SD)	S (Mean)	S (SD)
1	AI-driven digital skills are adequately embedded in the current building/woodwork TVET curriculum.	4.24	0.72	4.22	0.67	4.18	0.63
2	The use of AI tools improves students' understanding of modern building and woodwork processes.	4.32	0.56	4.28	0.61	4.21	0.54
3	Exposure to AI-based technologies has increased students' technical competence.	4.16	0.61	4.20	0.59	4,22	0.69
4	TVET graduates with AI training are more competitive in the job market.	4.21	0.68	4.19	0.66	4.28	0.57
5	Students can operate AI-enabled machines or software relevant to building and woodwork.	3.89	0.62	4.02	0.71	3.79	0.62
6	The application of AI enhances students' problem-solving and analytical skills.	4.25	0.59	4.30	0.63	4.17	0.54
7	Integrating AI tools into workshops improves the quality of project execution.	4.10	0.67	4.26	0.57	4.23	0.70
8	Graduates who are trained with AI tools tend to adapt better to technological changes in the industry.	4.27	0.54	4.21	0.62	4.26	0.50
9	Industry employers prefer hiring TVET graduates who are trained in AI-enhanced digital skills.	4.41	0.52	4.50	0.61	4.38	0.57
10	AI integration in building and woodwork education boosts innovation and creativity among students.	4.27	0.63	4.31	0.56	4.22	0.59

Table 1 highlights a shared optimism among lecturers, industry experts, and students about the growing role of AI in Building and Woodwork Technology education in Nigeria's TVET programs. Mean scores between 3.86 and 4.42 reflect strong agreement on AI's positive impact, with low variation across groups. All respondents agree that AI-driven skills are

now deeply woven into the curriculum, helping modernize TVET in line with industry demands. Students are engaging more deeply with construction concepts and developing stronger critical thinking and problem-solving abilities through AI tools.

However, while students understand AI in theory, their confidence drops when it comes to hands-on use of AI-powered machines, pointing to a need for better infrastructure and practical training. Despite this, there's a strong belief that AI is boosting technical competence and sparking creativity, especially in areas like simulation and smart design. AI-trained graduates are seen as more adaptable and market-ready, with Item 9 scoring the highest, underscoring AI's role in employability. Across all ten statements, the results suggest that AI isn't replacing traditional skills, it's enriching them.

Table 2: Challenges and Opportunities in AI Integration

S/N	Item Statement	L (Mean)	L (SD)	IE (Mean)	IE (SD)	S (Mean)	S (SD)
11	Lack of qualified trainers is a barrier to AI integration in TVET building/woodwork education.	4.21	0.64	4.09	0.58	4.15	0.60
12	TVET institutions lack the required infrastructure (hardware/software) for effective AI training.	4.47	0.58	4.39	0.62	4.42	0.65
13	There is high awareness of the relevance of AI in technical and vocational education.	4.29	0.61	4.32	0.52	4.32	0.55
14	Financial constraints hinder the adoption of AI technologies in building/woodwork training.	4.32	0.59	4.37	0.54	4.30	0.67
15	There is a strong willingness among lecturers and students to adopt AI tools for teaching and learning.	4.44	0.49	4.38	0.58	4.41	0.51
16	Government and private sector support for AI in TVET is insufficient.	4.47	0.52	4.45	0.60	4.38	0.54
17	Collaboration between industry and TVET institutions can ease AI adoption.	4.31	0.58	4.38	0.55	4.34	0.62
18	Opportunities exist for integrating AI into sustainable building/woodwork practices.	4.26	0.62	4.30	0.57	4.21	0.68
19	There are readily available AI-based teaching and learning materials suited for TVET.	4.18	0.68	4.20	0.62	4.13	0.57
20	Instructors face challenges in updating their knowledge to keep up with AI developments.	4.23	0.54	4.35	0.66	3.89	0.69

The findings from Table 2 reveal both significant challenges and promising opportunities in integrating AI into TVET, particularly in building and woodwork education. A major concern across all respondent groups is the shortage of qualified trainers, with lecturers most affected, pointing to an urgent need for AI-focused upskilling. Infrastructure deficits—especially in hardware and software, emerged as the top challenge, indicating institutions are not yet AI-ready. Financial constraints remain a persistent barrier, especially for instructors, underscoring the need for cost-effective solutions and external funding.

Respondents also highlighted weak government and private sector support, revealing a disconnect between policy and practical implementation. Despite these barriers, awareness of AI's importance is high, particularly among students, suggesting readiness for digital

transition. Lecturers showed the strongest willingness to adopt AI tools, reflecting a positive attitude toward innovation. All groups emphasized the importance of industry partnerships to drive AI integration and bridge training gaps.

There's growing recognition of AI's role in promoting sustainable construction and woodwork practices. However, access to specialized AI teaching resources remains limited, signalling the need for open-source content and localized materials. Instructors reported the most difficulty keeping up with AI trends, compared to more tech-savvy students, highlighting the generational digital divide and the need for ongoing faculty training.

Table 3: Strategies for Sustainable Growth and Economic Diversification

S/N	Item Statement	L (Mean)	L (SD)	IE (Mean)	IE (SD)	S (Mean)	S (SD)
21	Policy reforms are needed to incorporate AI into TVET education systems.	4.23	0.57	4.19	0.63	4.21	0.68
22	Periodic training and re-training of TVET instructors in AI tools will improve teaching quality.	4,33	0.64	4.29	0.59	4.31	0.51
23	Strategic industry-academia collaboration will enhance AI-based skills development in TVET.	4.27	0.63	4.21	0.54	4.24	0.65
24	TVET curriculum review is essential to accommodate AI trends in building and woodwork.	4,30	0.71	4.27	0.65	4.28	0.73
25	Government funding is crucial for implementing AI-focused programs in TVET.	4.29	0.56	4.32	0.63	4.38	0.61
26	Internship and apprenticeship programmes with AI exposure can boost graduates' work-readiness.	4.29	0.49	4.32	0.52	4.30	0.68
27	Incentives for industries that support AI-integration in TVET will foster stronger partnerships.	4.13	0.53	4.11	0.48	4.16	0.59
28	Inclusion of AI in technical vocational education will contribute to national economic diversification.	4.27	0.64	4.30	0.55	4.28	0.61
29	AI skills in TVET will help align graduates with sustainable industrial growth trends.	4.33	0.51	4.40	0.60	4.37	0.53
30	Establishing AI learning hubs in TVET institutions will drive innovation and entrepreneurship.	4.19	0.58	4.21	0.63	4.25	0.68

Table 3 reveals a strong, unified belief among lecturers, industry experts, and students that integrating AI into TVET, especially in building and woodwork, can drive sustainable growth and economic diversification. With mean scores ranging from 4.11 to 4.40, all ten strategies were positively endorsed, reflecting widespread confidence in AI's transformative potential.

Stakeholders strongly agreed that embedding AI skills into TVET would better align graduates with modern industrial needs. There was near-universal support for increased government funding to drive this integration, recognizing public investment as a key enabler. While still viewed positively, industry incentives received the lowest ratings, suggesting

some doubt about their current effectiveness or clarity.

Curriculum reforms, updated policies, and continuous professional development were all seen as vital steps to institutionalize AI in vocational education. Respondents also emphasized the importance of partnerships between TVET institutions and industry players to bridge training and workforce gaps. The establishment of AI learning hubs and structured internships was rated highly, highlighting a desire for practical, hands-on exposure.

Standard deviations were low across all groups, signalling strong consensus, although student responses varied slightly more, likely due to differences in AI access and learning experiences. Overall, the findings reflect an optimistic, well-aligned vision across stakeholders for AI to modernize Nigeria's TVET system and prepare youth for the digital economy.

Table 4: Analysis of Variance of AI-Driven Skills and Graduate Competence Among Respondent Groups (Lecturers, Industry Employers, and Students at 0.05 Level of Significance)

Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	F-value	p-value
Between Groups	—	2	—	0.727	0.487
Within Groups	—	63	—		
Total	—	65	—		

This study conducted a one-way Analysis of Variance (ANOVA) to determine whether statistically significant differences exist in the perceptions of Lecturers, Industry Employers, and Students regarding the integration and impact of AI-driven skills on graduate competence in the building and woodwork Technical and Vocational Education and Training (TVET) curriculum. As presented in the ANOVA summary table, the F-statistic was 0.727, with an associated p-value of 0.487 at 63 degrees of freedom within groups and 2 degrees of freedom between groups. This p-value is greater than the significance level of 0.05, indicating that the observed differences in group means are not statistically significant. More specifically, the group means were relatively close, 4.213 for Lecturers, 4.229 for Industry Employers, and 4.203 for Students, with low variability (standard deviations ranging from 0.103 to 0.143). These results suggest a broad consensus across all respondent groups concerning the positive impact of AI integration on skills development and graduate preparedness for the workforce.

Table 5: Analysis of Variance (ANOVA) of Sustainable Growth and Economic Diversification

Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	F-Ratio
Between Groups	0.070	2	0.035	0.098
Within Groups	22.338	63	0.355	
Total	**22.408**	**65**		

The study conducted a one-way Analysis of Variance (ANOVA) to investigate whether there were statistically significant differences in the perceptions of AI integration challenges and

opportunities among three distinct stakeholder groups in Technical and Vocational Education and Training (TVET) for building and woodwork technology: lecturers (n = 20)**,** industry experts (n = 16)**,** and students (n = 30)**.** The resulting F-ratio was 0.098**,** with a corresponding p-value of 0.917**.** Since the p-value exceeds the 0.05 level of significance, the result is not statistically significant**.** This implies that there is insufficient evidence to conclude that the differences in mean responses among the three groups are due to anything other than chance. The absence of statistically significant differences suggests a shared perception among lecturers, industry experts, and students regarding the challenges and opportunities associated with integrating artificial intelligence into TVET curricula for building and woodwork technology. Despite their varying roles within the educational and industrial ecosystem, stakeholders appear to converge in their understanding and assessment of key issues such as infrastructure limitations, financial constraints, readiness to adopt AI tools, and the necessity for government and private sector support. This consensus reinforces the rationality of the identified challenges and opportunities, suggesting that policy interventions and capacity-building strategies aimed at improving AI integration should be designed holistically**,** taking into account the mutual concerns and expectations of all stakeholders in the TVET sector.

Table 6: One-Way ANOVA Summary Table – Perceptions of AI Integration Strategies in TVET

Source of Variation	Sum of Squares (SS)	Df	Mean Square (MS)	F-Ratio	p-value
Between Groups	0.0039	2	0.0020	0.0058	> 0.05
Within Groups	21.2600	63	0.3375		
Total	21.2639	65			

A one-way analysis of variance (ANOVA) was conducted to determine whether there were statistically significant differences in the perceptions of Lecturers (n = 20), Industrial Experts (n = 16), and Students (n = 30) regarding strategies for sustainable growth and economic diversification through AI integration in TVET. The results revealed no significant difference among the groups' mean responses, $F(2, 63) = 0.0058$, $p > 0.05$. This suggests that the stakeholders share a consistently high level of agreement on the importance and relevance of the proposed AI strategies in TVET curriculum and practice. The low F-ratio indicates that variability within groups far exceeds variability between groups, reinforcing the consensus across stakeholder types. This consensus may reflect a shared recognition of the urgency and value of integrating AI to promote sustainable development and economic diversification through technical and vocational education. These findings support the view that policy formulation and implementation efforts can proceed with confidence, given the alignment across key stakeholder groups.

Discussion of Findings

This study paints a compelling picture of how integrating AI-driven digital skills into Building and Woodwork Technology Education can reshape the future of technical and vocational education and training (TVET) in emerging economies. At its core, the research underscores a shared optimism among lecturers, industry professionals, and students about the transformative potential of AI in revitalizing vocational learning. Their voices converge around a central truth: as labour markets evolve, so too must our educational system, and AI is a crucial catalyst for this change.

One of the most striking findings is the growing presence of AI tools and digital platforms in the TVET curriculum. These technologies aren't just trendy add-ons; they're equipping students with stronger technical competencies, sharper problem-solving skills, and better positioning in the job market. This affirms the vision of Abdullah et al. (2025), who argue that AI-enhanced training can ignite local innovation and bolster industrial competitiveness. From smart construction methods to digital fabrication, the fusion of traditional craftsmanship with AI is seen not as a replacement, but as a reinvention of skills for global relevance (Yadav *et al.*, 2022; Yin *et al.*, 2023).

Yet, despite the excitement, a critical gap persists. While students and instructors understand the *conceptual* benefits of AI, their confidence in hands-on application, like operating AI-powered machines, is noticeably lower (Mean = 3.79–4.02). This mirrors the observations of Charles et al. (2023), highlighting a disconnect between theory and practice. The message is clear: without the necessary infrastructure and practical training opportunities, the promise of AI remains largely untapped.

Barriers such as insufficient funding, a shortage of qualified trainers, and poor digital infrastructure emerged as recurring themes (see Table 2). These aren't just technical issues, they represent systemic challenges that limit access and stifle innovation. The reality described by Agbeyangi and Suleman (2024) is echoed here: many TVET institutions in developing contexts are simply not equipped to support advanced digital learning environments. However, the resilience and readiness among both educators and students shine through. The study reveals a widespread willingness to embrace AI tools, if only the right structures and support systems were in place.

One solution lies in closer collaboration between academia and industry. Participants strongly endorsed such partnerships (Item 17, Mean = 4.31–4.38), emphasizing the need for real-world exposure and continuous upskilling. This aligns with Kebede et al.'s (2024) work, which stresses the value of synergistic partnerships in modernizing vocational education. There's also growing recognition of AI's role in promoting sustainability. Stakeholders agreed that AI can improve energy efficiency, reduce waste, and support environmentally responsible construction practices, an idea strongly supported by Yitmen et al. (2025).

When asked about the way forward, respondents didn't hesitate: policy reform, curriculum redesign, and robust government funding are all crucial (Table 3). These findings echo Anam et al.'s (2024) call to align educational reform with national development priorities, including Nigeria's Economic Recovery and Growth Plan (ERGP). Participants also strongly advocated for the establishment of AI learning hubs and the inclusion of structured industry internships (Items 26 & 30), echoing Ghosh and Ravichandran's (2024) emphasis on the importance of hands-on, experiential learning in technical fields. The belief that AI skills can help diversify the economy, moving it away from overdependence on extractive industries, was a resounding theme, consistent with the insights of Esposito and Kapoor (2022).

Importantly, the ANOVA analysis revealed no significant differences in perceptions among the various stakeholder groups (Tables 4–6). This unanimity, across lecturers, students, and industry experts, reinforces the urgency of coordinated action. Everyone is on the same page: the time for digital transformation in TVET is now. These shared perspectives strengthen Morel et al.'s (2021) argument that blending indigenous practices with cutting-edge digital tools can create uniquely sustainable, locally grounded solutions that still meet international standards.

In sum, this study doesn't just highlight opportunities, it signals a collective readiness to embrace a new era in vocational education. With the right policies, partnerships, and infrastructure, AI has the potential to transform TVET from a reactive system into a proactive engine of economic diversification, innovation, and sustainability.

Conclusion

This study affirms the transformative potential of integrating AI-driven digital skills into Building and Woodwork Technology Education within TVET systems in emerging economies. By aligning vocational training with evolving industry demands, AI offers a powerful pathway to bridge the traditional skills gap, boost youth employability, and accelerate economic diversification. The consensus among students, educators, and industry experts signals a collective readiness for this shift. However, to realize this potential, systemic barriers must be addressed through intentional policy, investment, and collaboration.

Recommendations

1. Governments must place AI at the centre of TVET reform agendas, tying its implementation to national development goals.
2. Institutions need targeted funding for AI labs, digital tools, low-bandwidth solutions, and creative maker spaces to support hands-on learning.
3. Ongoing professional development in AI technologies is essential to equip educators with the skills to teach and mentor effectively.
4. Partnerships with the private sector should guide curriculum updates and open up opportunities for internships, apprenticeships, and joint innovation.
5. AI tools should be strategically deployed to support green construction, energy efficiency, and circular economy practices.

By focusing on these areas, emerging economies can unlock the full value of AI in technical education, empowering a new generation of skilled, innovative, and environmentally conscious graduates ready to contribute meaningfully to sustainable industrial development.

References

Abdullah, M. I., Hajamydeen, A. I., & Johar, M. G. M. (2025). Transforming TVET with AI: Economic Benefits of Technological Innovation in Education. *Online Journal for TVET Practitioners*, *10*(1), 69-86. https://publisher.uthm.edu.my/ojs/index.php/oj-tp/article/view/20647

Agbeyangi, A., & Suleman, H. (2024, November). Advances and Challenges in Low-Resource-Environment Software Systems: A Survey. In *Informatics* (Vol. 11, No. 4, p. 90). MDPI. https://doi.org/10.3390/informatics11040090

Anam, B. E., Ijim, U. A., Ironbar, V. E., Otu, A. P., Duke, O. O., & Achuk Eba, M. B. (2024). Economic recovery and growth plan, economic sustainability plan and national development plan (2021-2025): The Nigerian experience under President Muhammadu Buhari. *Cogent Social Sciences*, *10*(1), 2289600. https://doi.org/10.1080/23311886.2023.2289600

Charles, K., Song, Z., Gottlieb Ndambo Djaya, H., & Author, C. (2023). TVET and Socio-economic Development in Uganda: Lessons from Chinese TVET. *North American Academic Research*, *11*., 6(11), 54-69 https://doi.org/10.5281/zenodo.10214473

Esposito, M., & Kapoor, A. (2022). *the Emerging Economies under the dome of the Fourth industrial revolution*. Cambridge University Press. DOI: https://doi.org/10.1017/9781009092142

.Ghosh, L., & Ravichandran, R. (2024). Emerging technologies in vocational education and training. *Journal of Digital Learning Education*, *4*(1),49.**DOI:** https://doi.org/10.52562/jdle.v4i1.975

.Kebede, A., Asgedom, A., & Asfaw, A. (2024). Is linking technical and vocational training with industry a bridge to employability? Lessons from a literature review for Ethiopia. *Cogent Education*, *11*(1), 2406721. https://doi.org/10.1080/2331186X.2024.24067219

Morel, J. C., Charef, R., Hamard, E., Fabbri, A., Beckett, C., & Bui, Q. B. (2021). Earth as construction material in the circular economy context: practitioner perspectives on barriers to overcome. *Philosophical Transactions of the Royal Society B*, *376*(1834), 20200182. https://doi.org/10.1098/rstb.2020.0182

Tran, T., Ho, M. T., Pham, T. H., Nguyen, M. H., Nguyen, K. L. P., Vuong, T. T., ... & Vuong, Q. H. (2020). How digital natives learn and thrive in the digital age: Evidence from an emerging economy. *Sustainability*, *12*(9), 3819. **https://doi.org/10.3390/su12093819**

Yadav, U. S., Tripathi, R., & Tripathi, M. A. (2022). Global handicraft index: a pioneering approach and developing strategies for promotion completion and Welfare of Artisan in the Digital World. *Bank and policy*, *2*(1), 59-80 http://dx.doi.org/10.29228/imcra.18

Yin, X., Guo, C., Sun, B., Chen, H., Wang, H., & Li, A. (2023). The state of the art in digital construction of clay buildings: reviews of existing practices and recommendations for future development. *Buildings*, *13*(9), 2381. **https://doi.org/10.3390/buildings13092381**

Yitmen, I., Almusaed, A., Hussein, M., & Almssad, A. (2025). AI-Driven Digital Twins for Enhancing Indoor Environmental Quality and Energy Efficiency in Smart Building Systems. *Buildings*, *15*(7), 1030. **https://doi.org/10.3390/buildings15071030**

ARTIFICIAL INTELLIGENCE-BASED DEFECT DETECTION SYSTEMS FOR ENHANCING QUALITY CONTROL IN NIGERIA'S CONSTRUCTION INDUSTRY

[1]ALHASSAN Usman Ndagi, PhD, [2]ARAH Abubakar Saidu PhD & ISAH Yahaya PhD
[1]Department of Technical and Vocational Education,
Abdulkadir Kure University, Minna, Nigeria
[2]Department of Motor Vehicle Mechanic Works,
Vocational Enterprises Institute, Karshi, Abuja, Nigeria.
Department of Building Technology,
Niger State College of Education Minna, Nigeria.
Email: algogogius@gmail.com
Phone: +2348069044502

Abstract
This study explored artificial intelligence-based defect detection systems for enhancing quality control in Nigeria's construction industry. A descriptive survey research design with cross-sectional approach was adopted, targeting 50 construction professionals including site engineers, project managers, and quality control officers in the Federal Capital Territory, Abuja. Data were collected using a structured 18-item Likert-scale questionnaire (reliability coefficient of 0.89) and analyzed using descriptive statistics with mean and standard deviation. A 96% response rate was achieved (48 out of 50 questionnaires). The findings revealed that AI-powered drones (mean=4.15) and computer vision systems (mean=4.02) are highly suitable for defect detection. Major barriers include lack of awareness (mean=4.18) and high implementation costs (mean=4.12). Key strategies for adoption include government incentives (mean=4.25) and targeted training (mean=4.20). The study recommended that construction firms collaborate with technology providers for gradual AI integration, government should provide financial incentives and infrastructure development, and policymakers should develop clear regulatory frameworks that guide the use of AI technologies for enhancing quality control in the construction industry.

Keywords: Artificial Intelligence, Defect Detection, Quality Control & Construction Industry

Introduction

The construction industry in Nigeria plays a pivotal role in the nation's socio-economic development, providing critical infrastructure and contributing significantly to employment and Gross Domestic Product (GDP). According to the National Bureau of Statistics (2024), the construction sector accounted for approximately 9.3% of Nigeria's GDP, with projections indicating steady growth driven by urbanisation, population expansion, and infrastructural development initiatives. Despite these positive contributions, the industry continues to face persistent challenges, including poor workmanship, substandard materials, and inadequate monitoring, which compromise project quality and safety (Olanrewaju *et al.*, 2023). These issues have led to frequent reports of structural failures, project delays, and high maintenance costs, underscoring the urgent need for more effective quality control approaches.

Quality control is an essential component of construction project management, aimed at ensuring that construction outputs meet predefined standards, client expectations, and regulatory requirements. Inadequate quality control practices have been identified as a major contributor to building failures and reduced service life of infrastructure in Nigeria (Adewuyi & Olatunji, 2022). Traditional quality control methods, which rely heavily on manual inspections and human expertise, are often time-consuming, prone to error, and

insufficient for detecting hidden or early-stage defects in construction processes. Consequently, there is growing recognition of the need to adopt advanced technologies that can enhance the accuracy, efficiency, and reliability of defect detection and quality assurance in construction projects such as Artificial intelligence (AI)-based defect detection systems.

Artificial intelligence (AI)-based defect detection systems have emerged as a transformative solution for addressing quality control challenges in the global construction industry. These systems leverage machine learning, computer vision, and data analytics to automate the detection of defects such as cracks, deformations, and material inconsistencies with greater precision and speed compared to conventional methods (Fang *et al.*, 2023; Park *et al.*, 2024). AI-powered systems have been successfully applied in developed countries to monitor structural health, predict failures, and improve construction outcomes. However, their application within the Nigerian construction context remains limited, with existing studies primarily focused on general AI adoption rather than targeted quality control applications (Oluwafemi & Abiola, 2024).

Given the persistent quality challenges facing Nigeria's construction industry and the global shift towards AI-driven quality management, there is a clear need to investigate the suitability, adoption barriers, and strategic integration of AI-based defect detection systems within the Nigerian context. This study is therefore essential as it seeks to explore appropriate AI technologies for defect detection, identify the limitations hindering their adoption, and propose practical strategies to facilitate their integration.

Statement of the Research Problem

In an ideal construction industry, quality control processes are expected to be efficient, accurate, and reliable, ensuring that all construction projects meet prescribed standards, client expectations, and regulatory requirements. However, the current situation in Nigeria’s construction industry significantly deviates from this ideal. Despite the industry's critical role in national development and infrastructure delivery, quality control practices remain largely manual, labour-intensive, and prone to inaccuracies. Defects such as cracks, material inconsistencies, and structural weaknesses often go undetected during construction, leading to frequent cases of substandard buildings, structural failures, and in extreme instances, building collapse (Olanrewaju *et al.*, 2023; Adewuyi & Olatunji, 2022). The industry continues to grapple with quality-related challenges despite advancements in construction technology globally.

This quality control challenge has persisted for over two decades, with reports of building collapses and poor construction quality being a recurring issue in Nigeria (Olanrewaju *et al.*, 2023). Researchers and industry experts have made efforts to address these challenges through advocacy for improved construction practices, training of professionals, and limited technological interventions. Some studies have highlighted the potential of digital technologies such as Building Information Modelling (BIM) and general AI applications to enhance project delivery in Nigeria (Oluwafemi & Abiola, 2024). However, there remains a significant gap in the targeted adoption and integration of artificial intelligence-based defect detection systems specifically designed to improve quality control in the Nigerian construction sector.

Despite these efforts, the challenge of poor quality control and undetected construction defects persists, partly due to limited awareness, infrastructural limitations, resistance to technological change, and the high cost of advanced AI technologies (Adewuyi & Olatunji, 2022). If these challenges are not adequately addressed, the consequences could be severe, including increased project failures, higher maintenance costs, safety risks to building

occupants, erosion of public trust in the construction industry, and significant economic losses. This study, therefore, sought to address the persistent quality control challenge by exploring artificial intelligence-based defect detection systems for enhancing quality control in Nigeria's construction industry

Aim and Objectives of the Study

The aim of this study was to explore artificial intelligence-based defect detection systems for enhancing quality control in Nigeria's construction industry. The specific objectives of this study were to:

1. Explore artificial intelligence-based systems suitable for defect detection in Nigeria's construction industry.
2. Identify the barriers hindering the adoption of artificial intelligence-based defect detection systems in Nigeria's construction industry.
3. Determine strategies to facilitate the adoption of artificial intelligence-based defect detection systems for enhancing quality control in Nigeria's construction industry.

Research Questions

The following research questions were raised and answered:

1. What are the artificial intelligence-based systems suitable for defect detection in Nigeria's construction industry?
2. What are the barriers hindering the adoption of artificial intelligence-based defect detection systems in Nigeria's construction industry?
3. What strategies to facilitate the adoption of artificial intelligence-based defect detection systems for enhancing quality control in Nigeria's construction industry?

Methodology

This study adopted a descriptive survey research design with a cross-sectional approach. The design was considered appropriate because it enables the systematic collection and analysis of data from a defined population at a specific point in time to explore opinions, perceptions, and experiences relevant to the study (Creswell & Creswell, 2023). The area of the study was the Federal Capital Territory (FCT), Abuja, Nigeria. The population of the study was 50 construction professionals that comprised 20 site engineers, 15 project managers, and 15 quality control officers from 10 selected construction companies within the Federal Capital Territory (FCT), Abuja, Nigeria, registered with the Council for the Regulation of Engineering in Nigeria (COREN) and the Federation of Construction Industry (FOCI) as of 2024. The construction companies were selected using purposive sampling based on their active involvement in large-scale construction projects within the FCT. Due to the manageable size of the population, the whole population was used for the study without employing any further sampling technique.

Data for the study were collected using a structured Likert-scale questionnaire consisting of 18 items designed to address the three research questions. The response options were Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree, rated on a five-point scale of 5, 4, 3, 2, and 1, respectively. The first six items explored artificial intelligence-based systems suitable for defect detection in Nigeria's construction industry. The next six items examined barriers hindering the adoption of AI-based defect detection systems, while the final six items focused on strategies to facilitate the adoption of such systems for enhancing quality control. The instrument was subjected to face and content validation by three experts, one each from the fields of construction management, information and communication technology, and engineering education. These experts reviewed the

instrument to ensure its clarity, relevance, and alignment with the study's objectives and research questions. To ensure the reliability of the instrument, a pilot test was conducted using 10 construction professionals from similar organizations outside the main study area. The internal consistency of the instrument was estimated using the Cronbach's Alpha method, which yielded a reliability coefficient of 0.89. According to Tavakol and Dennick (2021), a coefficient value of 0.70 and above indicates high reliability, confirming that the instrument was suitable for the study.

Questionnaires were administered in both physical and electronic formats with the assistance of research aides familiar with the selected construction firms. Out of the 50 questionnaires distributed, 48 were correctly filled and retrieved, representing a 96% response rate. Data collected were analyzed using descriptive statistics, specifically mean and standard deviation, to answer the research questions. The decision rule for interpreting the mean scores was based on real limits of numbers.

Results:

Research Question 1
What are the artificial intelligence-based systems suitable for defect detection in Nigeria's construction industry? Results for answering research question one are displayed in Table 1.

Table 1: Mean and standard deviation of the respondents' responses on the artificial intelligence-based systems suitable for defect detection in Nigeria's construction industry

S/N	Items	Mean	SD	Remark
1	Machine learning models can be effectively applied to detect construction defects.	3.85	0.88	Agreed
2	Computer vision systems are suitable for identifying surface defects in construction materials and structures.	4.02	0.91	Agreed
3	Deep learning techniques can enhance the accuracy of defect detection in construction projects.	3.96	0.85	Agreed
4	The use of drones equipped with AI capabilities is suitable for inspecting hard-to-reach areas of construction sites.	4.15	0.79	Agreed
5	AI-powered sensors can reliably monitor structural integrity during and after construction.	3.78	0.94	Agreed
6	Natural language processing can be useful in interpreting defect reports and enhancing decision-making in construction projects.	3.66	0.92	Agreed
	Grand Mean	**3.90**	**0.88**	**Agreed**

Table 1 shows the mean and standard deviation for respondents' views on the artificial intelligence-based systems suitable for defect detection in Nigeria's construction industry. The grand mean of 3.90 with a standard deviation of 0.88 indicates that respondents agreed that AI-based systems such as machine learning, computer vision, deep learning, drones, AI-powered sensors, and natural language processing are suitable for defect detection in the construction industry.

Research Question 2

What are the barriers hindering the adoption of artificial intelligence-based defect detection systems in Nigeria's construction industry? Results for answering research question two are displayed in Table 2.

Table 2: Mean and standard deviation of the respondents' responses on the barriers hindering the adoption of artificial intelligence-based defect detection systems in Nigeria's construction industry

S/N	Items	Mean	SD	Remark
1	High costs of acquiring and implementing AI-based defect detection systems hinder their adoption.	4.12	0.83	Agreed
2	Limited technical expertise within the construction industry affects the adoption of AI-based defect detection systems.	4.08	0.85	Agreed
3	Resistance to technological change by construction professionals limits the adoption of AI-based defect detection systems.	3.96	0.89	Agreed
4	Poor internet infrastructure and digital connectivity hinder the effective use of AI-based technologies in construction.	4.05	0.87	Agreed
5	Lack of awareness of the benefits of AI-based defect detection systems is a major barrier in Nigeria's construction industry.	4.18	0.81	Agreed
6	Inadequate government policies and regulations discourage the adoption of AI-based defect detection systems.	4.1	0.84	Agreed
	Grand Mean	**4.08**	**0.85**	**Agreed**

Table 2 shows the mean and standard deviation for respondents' views on the barriers hindering the adoption of artificial intelligence-based defect detection systems in Nigeria's construction industry. The grand mean of 4.08 with a standard deviation of 0.85 indicates that respondents agreed that high costs, limited expertise, resistance to change, poor infrastructure, lack of awareness, and inadequate policies are major barriers to the adoption of AI-based defect detection systems.

Research Question 3

What strategies to facilitate the adoption of artificial intelligence-based defect detection systems for enhancing quality control in Nigeria's construction industry? Results for answering research question three are displayed in Table 3.

Table 3: Mean and standard deviation of the respondents' responses on the strategies to facilitate the adoption of artificial intelligence-based defect detection systems for enhancing quality control in Nigeria's construction industry

S/N	Items	Mean	SD	Remark
1	Providing targeted training and capacity building for construction professionals will facilitate the adoption of AI-based defect detection systems.	4.2	0.78	Agreed
2	Government incentives and funding schemes are necessary to encourage the adoption of AI-based defect detection systems.	4.25	0.75	Agreed

3	Strengthening digital infrastructure will promote the effective use of AI-based defect detection systems in construction projects.	4.18	0.8	Agreed
4	Creating awareness on the benefits of AI-based defect detection systems will enhance their acceptance in the construction industry.	4.22	0.77	Agreed
5	Encouraging collaborations between construction companies and technology providers will support the integration of AI-based defect detection systems.	4.16	0.82	Agreed
6	Developing clear regulatory frameworks for AI applications in construction will facilitate the safe and effective adoption of AI-based defect detection systems.	4.24	0.79	Agreed
	Grand Mean	**4.21**	**0.79**	**Agreed**

Table 3 shows the mean and standard deviation for respondents' views on the strategies to facilitate the adoption of artificial intelligence-based defect detection systems for enhancing quality control in Nigeria's construction industry. The grand mean of 4.21 with a standard deviation of 0.79 indicates that respondents agreed that targeted training, government incentives, improved infrastructure, awareness campaigns, collaborations, and regulatory frameworks are essential strategies to facilitate AI-based defect detection system adoption.

Findings

- Machine learning models, computer vision systems, deep learning techniques, AI-powered drones, smart sensors, and natural language processing were found to be suitable artificial intelligence-based systems for defect detection in Nigeria's construction industry.
- High costs, limited technical expertise, resistance to technological change, poor digital infrastructure, lack of awareness, and inadequate government policies were found to be major barriers hindering the adoption of artificial intelligence-based defect detection systems in Nigeria's construction industry.
- Targeted training, government incentives, improved digital infrastructure, awareness creation, collaboration with technology providers, and clear regulatory frameworks were found to be effective strategies for facilitating the adoption of artificial intelligence-based defect detection systems for enhancing quality control in Nigeria's construction industry.

D**iscussion of Findings**

The findings on research question one revealed that machine learning models, computer vision systems, deep learning techniques, AI-powered drones, smart sensors, and natural language processing were found to be suitable artificial intelligence-based systems for defect detection in Nigeria's construction industry. This finding aligns with global research that has highlighted the significant potential of artificial intelligence (AI) in improving the accuracy and efficiency of defect detection processes in construction projects. For instance, Zhang *et al*. (2023) emphasized that machine learning and deep learning techniques can analyze large volumes of construction data to automatically detect patterns, anomalies, and defects that may not be easily visible to human inspectors. Similarly, computer vision systems, particularly those powered by convolutional neural networks (CNN), have been successfully

applied for detecting cracks, corrosion, and other surface defects in building materials and structures, offering faster and more reliable inspection outcomes (Wang *et al.,* 2022).

In addition, the use of AI-powered drones has gained global recognition as a reliable solution for inspecting hard-to-reach areas of construction sites, improving safety, and enhancing the early detection of structural defects (Alkass *et al.,* 2022). The application of smart sensors in monitoring structural health and detecting real-time anomalies during and after construction has also been reported as an effective tool for minimizing risks associated with undetected defects (Mousavi *et al.,* 2023). Furthermore, recent studies have demonstrated that natural language processing (NLP) techniques can assist in interpreting defect reports, maintenance logs, and technical documents, thereby enhancing decision-making processes in construction project management (Li *et al.,* 2024). These AI-based systems collectively contribute to minimizing human error, reducing inspection time, and improving the overall quality control processes in the construction industry.

The suitability of these AI technologies for defect detection in Nigeria's construction industry is particularly critical, given the recurring challenges of substandard construction practices, structural failures, and building collapses reported across the country (Olanrewaju *et al.,* 2023). Although the adoption of these technologies remains limited within the Nigerian construction sector, their proven effectiveness in other countries provides a compelling case for their integration to enhance quality control and project safety in Nigeria. In summary, this study's finding is consistent with the growing body of international literature, affirming that AI-based systems offer practical, efficient, and reliable solutions for improving defect detection in construction, which is essential for ensuring structural integrity and reducing the incidence of construction failures.

The findings on research question two revealed that high costs, limited technical expertise, resistance to technological change, poor digital infrastructure, lack of awareness, and inadequate government policies were found to be major barriers hindering the adoption of artificial intelligence-based defect detection systems in Nigeria's construction industry. This finding is consistent with several recent studies that have highlighted similar challenges to AI adoption, particularly in developing countries where infrastructural and technological gaps are prevalent. High costs of acquiring and implementing AI technologies have been widely reported as a significant barrier, especially in developing economies like Nigeria, where most construction firms operate with limited capital (Abubakar *et al.,* 2023). The cost of procuring advanced AI tools, coupled with the expenses associated with system maintenance and upgrades, discourages many firms from embracing such technologies, particularly small and medium-sized enterprises (SMEs) that dominate Nigeria's construction sector.

Moreover, limited technical expertise remains a persistent obstacle to the adoption of AI in construction. According to Adegbite *et al.* (2022), there is a general shortage of skilled personnel in Nigeria with the knowledge and competence required to develop, deploy, and manage AI-based systems, especially in technical industries like construction. This skills gap reduces the confidence of construction firms to invest in AI-driven defect detection solutions. Resistance to technological change by construction professionals, driven by fear of job displacement, lack of trust in AI systems, and skepticism about the effectiveness of these technologies, also contributes to the slow pace of AI adoption in the industry (Eze *et al.,* 2023). This challenge is compounded by poor digital infrastructure, such as inadequate internet connectivity and unreliable power supply, which undermines the effective deployment and operation of AI-based systems in construction sites across Nigeria.

Furthermore, the lack of awareness regarding the benefits and capabilities of AI-based defect detection systems limits their acceptance among construction stakeholders. As noted by Okonkwo *et al*. (2024), many construction professionals in Nigeria still rely heavily on manual inspection methods due to limited exposure to technological innovations in quality control. Additionally, the absence of clear government policies, standards, and regulatory frameworks for the integration of AI technologies in the construction sector creates uncertainty and discourages investment in AI-based systems. In summary, this study's findings corroborate existing literature, which emphasizes that without addressing these barriers, particularly cost, technical expertise, infrastructure, awareness, and policy gaps, the potential of AI to enhance defect detection and quality control in Nigeria's construction industry will remain largely untapped.

The findings on research question three revealed that targeted training, government incentives, improved digital infrastructure, awareness creation, collaboration with technology providers, and clear regulatory frameworks were found to be effective strategies for facilitating the adoption of artificial intelligence-based defect detection systems for enhancing quality control in Nigeria's construction industry. This finding is in agreement with existing global and local research, which emphasizes that overcoming technological, infrastructural, and human capacity barriers requires deliberate and coordinated strategies. Targeted training and capacity building have been consistently recommended as fundamental to bridging the technical skills gap and promoting AI adoption in the construction sector. According to Adegbite *et al*. (2022), providing training for construction professionals equips them with the competencies required to develop, deploy, and manage AI-based systems, thereby building confidence and trust in such technologies.

Government incentives and funding schemes are also widely acknowledged as vital for accelerating AI integration in developing countries where financial constraints hinder technological advancement. A recent study by Abubakar *et al*. (2023) emphasized that financial support through tax breaks, grants, and low-interest loans can encourage construction firms, particularly small and medium-sized enterprises, to invest in AI-based quality control systems. Improving digital infrastructure, such as reliable internet connectivity and power supply, is another critical strategy for enhancing the adoption of AI technologies. As highlighted by Eze *et al*. (2023), inadequate digital infrastructure remains one of the major obstacles to AI adoption in Nigeria, and addressing this challenge will create an enabling environment for the effective operation of AI-driven defect detection systems. The importance of awareness creation is also well documented in literature. Many construction professionals in Nigeria still have limited understanding of AI applications, which contributes to skepticism and low acceptance. Okonkwo *et al*. (2024) noted that targeted awareness campaigns, workshops, and stakeholder engagement can help demystify AI technologies and promote their acceptance in the construction industry.

In addition, collaboration between construction companies and technology providers plays a crucial role in facilitating AI adoption. Such partnerships provide opportunities for knowledge transfer, customized technology solutions, and technical support, as emphasized by Zhang *et al*. (2023) in their study on AI adoption in construction quality management. Finally, developing clear regulatory frameworks and policies is essential to guide the safe, ethical, and effective integration of AI technologies in construction. Without such frameworks, construction firms may hesitate to invest in AI-based systems due to legal uncertainties and operational risks (Wang *et al.,* 2022). In conclusion, this findings are consistent with international best practices and research evidence, confirming that a combination of human capacity development, policy reforms, infrastructure improvement, awareness creation, collaboration, and government support are key strategies for facilitating

the successful adoption of AI-based defect detection systems in Nigeria's construction industry.

Conclusion

This study investigated artificial intelligence-based defect detection systems for enhancing quality control in Nigeria's construction industry. The findings established that machine learning models, computer vision systems, deep learning techniques, AI-powered drones, smart sensors, and natural language processing are suitable technologies for detecting construction defects. However, the adoption of these technologies is hindered by high costs, limited technical expertise, resistance to technological change, poor digital infrastructure, lack of awareness, and inadequate government policies. The study also found that targeted training, government incentives, improved digital infrastructure, awareness creation, collaboration with technology providers, and clear regulatory frameworks are effective strategies for facilitating the adoption of AI-based defect detection systems to enhance quality control. These findings highlight the importance of embracing AI technologies to address persistent quality control challenges and reduce the incidence of structural defects and construction failures in Nigeria.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. Construction firms in Nigeria should collaborate with technology providers to gradually adopt suitable artificial intelligence-based defect detection systems such as machine learning, computer vision, and AI-powered drones by integrating them into their existing quality control processes through structured pilot programmes.
2. The Nigerian government, in partnership with professional bodies and construction industry associations, should reduce the barriers to AI adoption by providing financial incentives, subsidized training, and infrastructure development to equip construction professionals with the necessary resources and skills.
3. Policymakers and regulatory authorities should facilitate the adoption of artificial intelligence-based defect detection systems by developing and enforcing clear regulatory frameworks that guide the use of AI technologies for enhancing quality control in the construction industry.

References

Abubakar, I., Lawal, M., & Usman, A. (2023). Adoption of artificial intelligence in Nigeria's construction industry: Challenges and prospects. Journal of Engineering, Project, and Production Management, 13(1), 1-10. https://doi.org/10.2478/jeppm-2023-0001

Adegbite, T., Afolabi, A., & Olatunji, O. (2022). Exploring barriers to artificial intelligence adoption in the Nigerian construction industry. Built Environment Project and Asset Management, 12(5), 814-829. https://doi.org/10.1108/BEPAM-04-2022-0059

Adewuyi, T. O., & Olatunji, S. O. (2022). Quality management practices and building collapse in Nigeria: Challenges and prospects. Journal of Construction Research, 23(1), 45-58. https://doi.org/10.1080/15623599.2022.1878920

Alkass, S., Al-Hussein, M., & Mahmud, K. (2022). The role of drones and AI in construction defect detection: A systematic review. Automation in Construction, 137, 104241. https://doi.org/10.1016/j.autcon.2022.104241

Creswell, J. W., & Creswell, J. D. (2023). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (6th ed.). Sage Publications.

Eze, S. C., Chinedu-Eze, V. C., & Bello, A. O. (2023). Technology adoption in construction project management: The role of resistance to change in Nigeria. International Journal of Construction Management, 23(2), 179-191. https://doi.org/10.1080/15623599.2021.1955045

Fang, W., Zhang, J., & Li, X. (2023). Automated defect detection in construction using deep learning: A review. Automation in Construction, 152, 104911. https://doi.org/10.1016/j.autcon.2023.104911

Li, X., Yu, Y., & Han, Y. (2024). Leveraging natural language processing for construction defect management: A review and future directions. Journal of Construction Engineering and Management, 150(3), 04023106. https://doi.org/10.1061/(ASCE)CO.1943-7862.0002476

Mousavi, S., Khoshnevis, B., & Taghaddos, H. (2023). Smart sensor applications for structural health monitoring in construction: Benefits and challenges. Sensors, 23(2), 549. https://doi.org/10.3390/s23020549

National Bureau of Statistics. (2024). Nigerian Gross Domestic Product Report Q1 2024. Abuja: NBS.

Olanrewaju, A. O., Okafor, E. C., & Bello, R. A. (2023). Addressing construction project challenges in Nigeria through technology adoption: An empirical investigation. International Journal of Construction Management, 23(4), 553-566. https://doi.org/10.1080/15623599.2023.2165842

Okonkwo, U., Umeokafor, N., & Kolo, B. (2024). Overcoming technological barriers in construction quality management: Artificial intelligence as a solution for developing countries. Journal of Construction Innovation, 24(1), 33-48. https://doi.org/10.1108/CI-08-2023-0105

Oluwafemi, T. A., & Abiola, B. M. (2024). Emerging technologies and their impact on construction project delivery in Nigeria: A review. Nigerian Journal of Building Technology, 8(2), 87-102.

Park, J., Kim, S., & Lee, D. (2024). AI-driven inspection systems for improving construction safety and quality: Recent advances and future prospects. Journal of Civil Engineering and Management, 30(1), 24-39. https://doi.org/10.3846/jcem.2024.18302

Tavakol, M., & Dennick, R. (2021). Making sense of Cronbach's alpha. International Journal of Medical Education, 2, 53-55. https://doi.org/10.5116/ijme.4dfb.8dfd

Wang, Z., Zhang, C., & Xu, L. (2022). Deep learning-based visual inspection for defect detection in construction: Progress, challenges, and opportunities. Automation in Construction, 135, 104164. https://doi.org/10.1016/j.autcon.2022.104164

Zhang, Y., Liu, H., & Chen, F. (2023). A review of artificial intelligence applications in construction quality management. Journal of Construction Informatics, 17(1), 55-73.

BUILDING INFORMATION MODEL IN NIGERIA CONSTRUCTION INDUSTRY: BENEFITS AND BARRIERS

Dr. C.O. Igwe[1], Tsado, Elisha Garba[2], Dr. Ogbonna, Emeka[3] K. & I.S. Enagi[4]
[1&2]Department of Industrial and Technology Education, Federal University of Technology Minna, Nigeria.
[3]Agricultural Education, Faculty of Vocational & Technical Education University of Nigeria Nsukka.
[4]Department of Economics, Ibrahim Badamasi Babangida University Lapai, Niger State, Nigeria.
Email: christoigwe@gmail.com Mobile No: 08034040840

Introduction

Over time, stakeholders have often misunderstood the discussions surrounding the built environment and the construction industry, particularly regarding the need for greater project certainty, cost efficiency, and timely execution. Concurrently, the compelling trend of digitalization continues to grow, with numerous projects illustrating that digital workflows are becoming increasingly integrated, offering a real chance to revolutionize the delivery of major programs. Digital disruption can no longer be viewed as limited to Building Information Modeling (BIM) specialists or confined to model-based approaches; it is now a permanent aspect of the construction sector. Data and technology are enabling a new form of collaboration among project teams (Jon, 2022).

The construction industry has become more intricate and harder to manage due to low investment rates, escalating costs, heightened risks, waste, and a significant increase in labor productivity (Ibrahim & Ahmad, 2020). As a result, BIM emerges as a valuable solution focused on managing information and addressing building challenges. Digital technologies are being employed to enhance sustainability and productivity in the construction sector, streamlining procurement activities and project execution. Consequently, architects and construction professionals can now visualize and convert building designs and data into detailed information through innovative processes enabled by BIM.

Research increasingly supports the idea that digital technologies, like BIM, have significant potential to enhance the quality of services offered by design, engineering, construction, and real estate professionals (Charlesraj& Dinesh, 2020; Olawumi& Chan, 2019; Yin *et al.*, 2019). The introduction of computers and related technologies has notably impacted construction professionals (Othman *et al.*, 2022). Samimpay and Saghatforoush (2020) highlight that construction professionals, such as architects and civil engineers, primarily use BIM to visualize their designs before actual construction begins, thereby minimizing errors and saving costs for clients, as any changes made to the digital model or database are automatically updated throughout the entire model. Furthermore, Albert, Akanni and Onumisi (2024) argued that BIM has enhanced collaboration among architects, clients, engineers, building services, manufacturers, contractors, and other consultants involved in infrastructure projects, which was previously challenging.

The construction industry in Nigeria is rapidly expanding due to urbanization, infrastructure growth, and a rising population (Albert *et al.*, 2025). This growth has led to increased demand for sustainable construction practices that comply with global standards and the United Nations Sustainable Development Goals (Ahankoob, Manley &Abbasnejad, 2022). However, despite the potential advantages of BIM in meeting these objectives, its adoption in Nigeria remains low. Research by Oke et al. (2019) indicates that this is primarily due to challenges such as lack of awareness, insufficient training, high implementation costs, and resistance to change among stakeholders. Consequently, many construction projects in Nigeria continue to rely on traditional methods, leading to delays, cost overruns, and

environmental harm. While previous studies have identified barriers to BIM in Nigeria, none have quantified its effect on reducing material waste in sustainable projects. The urgency to adopt innovative technologies like BIM is growing, especially as the Nigerian government and various stakeholders advocate for greener construction practices to address climate change. BIM provides a valuable opportunity to integrate sustainability into the planning, design, and construction phases of building projects.

Concept of Building Information Model

The building construction industry has experienced significant changes in its manufacturing methods and operational procedures over the years (Popoola *et al.,* 2024). From conception through to delivery and completion, the core product of the industry buildings continually undergoes innovation, modification, and transformation. A notable recent advancement in this field is Building Information Modeling (BIM), which represents a fundamental shift in the architecture, engineering, and construction (AEC) sectors, fundamentally changing how projects are designed, constructed, and managed.

BIM is an innovative approach to building design, construction, and management that has reshaped how industry experts view the application of technology both nationally and internationally (Azhar, 2011). Its introduction has been one of the most significant advancements in building design, management, maintenance, and operations (Ayarici *et al.,* 2009). These innovations have equipped project teams with new communication formats and collaborative tools that engage multiple senses. BIM provides sophisticated analytical tools and decision-making instruments that model and replicate both real and conceptual structures and environments, thus significantly impacting building procurement.

BIM Dimensions

Parametric 3D Modelling (3D BIM); 3D BIM enables work in three dimensions, applying construction logic within a virtual environment. This means that any changes made in one part of the model are automatically reflected in other areas, eliminating the need for manual updates. Starting with a three-dimensional perspective allows all professionals and project stakeholders to make better decisions and minimizes changes during project execution (Staub-French &Khanzode, 2007). Foster (2008) explains that building components are analyzed using clash detection tools to identify and resolve conflicts before installation in the field. The ability of construction managers and specialized contractors to perform 3D coordination prior to construction significantly reduces design errors and enhances understanding of the work required (Young *et al.,* 2009).

BIM-Based Scheduling (4D BIM): In the past decade, research on scheduling has evolved from 3D CAD model-supported construction to 3D BIM with enhanced information-based scheduling (time) (Harrison & Thurnell, 2015; Liu *et al.,* 2014). 4D BIM technology links 3D BIM models to associated activities, following the principles of the Critical Path Method (CPM). This integration enables users to run simulations of the project to identify and resolve spatial and temporal conflicts, thereby improving project performance (Elghaish *et al.,* 2018; Zigurat, 2018). Keegan (2010) notes that incorporating scheduling into the virtual construction process introduces time as the fourth dimension (4D BIM). In CPM, activities are listed, linked by their dependencies, and assigned durations, with each activity serving as either a predecessor or successor based on the planned execution order.

Cost Estimation (5D BIM): 5D BIM technology automates measurements and project cost estimation, often by directly linking modeling software to cost control software. Since the budget is derived from the project design, cost values are based on actual measurements rather than estimates (Zigurat, 2018). Elghaish et al. (2018) explain that 5D BIM facilitates cost planning and prepares bills of quantities (BoQ). Noor, Scott, and Robert (2016) highlight that BIM improves the reliability of cost estimates, provides early schedule information, quickly predicts the cost impact of design changes, enhances understanding

through better visualization, and increases access to documentation. Makenya and Ally (2018) argue that BIM allows estimators to identify relationships between quantities, costs, and locations, and to understand how various components of a construction project contribute to the overall cost.

Green Design (6D BIM): Improving energy efficiency and utilizing renewable energy sources have become global priorities, prompting many governments to support and promote BIM adoption. Rising energy costs for electricity, gas, and water have motivated building owners to integrate features that reduce energy consumption. Unlike CAD programs, BIM tools enable energy analysis by incorporating the technical properties of materials used in the project (Harrison & Thurnell, 2015; Zigurat, 2018).

Facility Management(7D BIM): The operational phase of a building is often the most costly part of its lifecycle. BIM provides better control over the information and documentation generated by a building's properties, which is a key reason public administrations are eager to transition from outdated systems to fully functional BIM systems (Zigurat, 2018).

Benefits of BIM

Building Information Modeling (BIM) provides substantial advantages in construction projects by improving efficiency, minimizing waste, and fostering collaboration among stakeholders (Gourlis&Kovacic, 2017). A key benefit of BIM is its ability to create accurate, detailed 3D models that enhance planning and visualization (Djuedja *et al.,* 2018; Chong *et al.,* 2017). This feature helps project teams identify potential design problems early, reducing the need for costly rework and ensuring efficient resource use. BIM also enables precise material quantification and scheduling, lowering the chances of over-ordering and waste, which supports sustainable resource management (Nechyporchuk&Bašková, 2020).

Additionally, Oladiran, Simeon &Anyira (2022) noted that BIM enhances energy efficiency by integrating with energy modeling tools that simulate a building's performance under different conditions. This allows architects and engineers to assess design alternatives and make informed decisions to improve energy performance, such as optimizing insulation, choosing energy-efficient systems, and incorporating renewable energy sources. Consequently, projects utilizing BIM can achieve lower operational costs and reduced carbon footprints, aligning with global sustainability goals and enhancing the building's longevity (Chen *et al.,* 2017).

Collaboration is another vital benefit of BIM in sustainable construction. The platform improves communication among architects, engineers, contractors, and owners by providing a centralized model accessible to all stakeholders (Albert, Shakantu& Ibrahim, 2020; Rowlinson, 2017). This collaborative environment ensures alignment on project goals and sustainability objectives, facilitating better decision-making throughout the project lifecycle. As a result, BIM not only streamlines workflows but also enhances the overall quality and sustainability of construction projects, making it an essential tool for environmentally responsible building practices.

Barriers to Implementing BIM

The adoption of Building Information Modeling (BIM) in sustainable construction projects is hindered by several barriers (Succar, 2009). Technologically, the high costs associated with BIM software and the limited interoperability between different platforms pose significant challenges (Teicholz, 2014). Many organizations lack the necessary hardware and infrastructure to support BIM, and integrating it with existing systems can be complex and resource-intensive. Additionally, the scarcity of BIM-compatible tools complicates implementation, especially for smaller firms that may not have the financial and technical resources required.

Organizationally, a shortage of trained personnel and resistance to change are major obstacles. Many companies face budget constraints that result in inadequate organizational structures to support BIM initiatives (Silva *et al.,* 2016). Insufficient support from top management further complicates these challenges, hindering a unified approach to BIM integration (Siew, 2015).

Culturally, a lack of collaboration and communication among project stakeholders can impede effective data sharing and information flow (Nasila&Cloete, 2018; Albert, Shakantu& Ibrahim, 2018). Resistance to data sharing often arises from differing work cultures and languages, leading to misunderstandings about BIM's benefits and potential conflicts between traditional practices and modern approaches (Sinclair, 2012). Lastly, regulatory barriers, such as the absence of clear regulations and standards, can create confusion regarding BIM adoption, while limited enforcement and inconsistent building codes can stifle innovation. Without adequate government support to encourage BIM adoption, the construction industry may continue to face significant challenges in leveraging BIM for sustainable practices.

Conclusion

In conclusion, Building Information Modeling (BIM) presents a transformative opportunity for the construction industry, significantly enhancing efficiency, sustainability, and collaboration among stakeholders. By providing detailed 3D models, BIM enables early identification of design issues, reducing costly rework and waste while promoting effective resource management. Additionally, its integration with energy modeling tools supports informed decision-making that optimizes energy performance, aligning construction projects with global sustainability goals. The collaborative nature of BIM fosters improved communication among architects, engineers, contractors, and owners, ensuring that all parties are aligned on project objectives and sustainability initiatives.However, the successful implementation of BIM is not without its challenges. Technological barriers, such as high software costs and limited interoperability, hinder adoption, particularly for smaller firms lacking the necessary resources. Organizational issues, including insufficient training and resistance to change, further complicate integration efforts. Cultural barriers, characterized by a lack of collaboration and communication, along with regulatory uncertainties, create additional obstacles for the construction industry. Addressing these challenges through enhanced support, training, and regulatory frameworks remain essential for fully realizing the potential of BIM in promoting sustainable construction practices.

Reference

Ahankoob, A. Manley, K. & Abbasnejad, B. (2022). The role of contractors' building information modelling (BIM) experience in realising the potential values of BIM. *International Journal of Construction Management*, 22(4), 588-599.

Albert, I. Nathaniel, O. B. &Olonilebi, P. (2025). Investigation of Building Information Modeling (Bim) .n Sustainable Construction Projects. *FUDMA Journal of Sciences (FJS)*, 9(2), 133 - 139 DOI: https://doi.org/10.33003/fjs-2025-0902-3121

Albert, I., Alake, O., Akanni, P., & Onimisi, E.O., (2024). The Impacts of Technology Integration in Construction for Project Delivery. *Journal of Agricultural and Environmental Science Research*. 6(1), 118-131.

Albert, I., Shakantu, W. and Ibrahim, K., (2018). Impact of Materials Management Practices in the Nigerian Building Construction industry. *Journal of Construction Project Management and Innovation*, 8(1), 1789-1796.

Ayarici, Y. Khosrowshahi, F. Ponting, A. M. & Mihindu, S. (2009). Towards implementation of Building Information Modeling in the construction industry. Proc.

Fifth International Conference on Construction in the 21st Century (CITC-V): Collaboration and Integration in Engineering, Management and Technology.

Azhar, S. (2011). Building information modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry. *Leadership and Management in Engineering*, 11(3), 241-252.

Charlesraj, V. P. C., & Dinesh, T. (2020). *Status of 4D BIM Implementation in Indian Construction. Proceedings of the 37th International Symposium on Automation and Robotics in Construction, ISARC 2020*: From Demonstration to Practical Use - To New Stage of Construction Robot, October , 199206 . https://doi.org/10.22260/isarc2020/0 030

Chen, K., Xu, G., Xue, F., Zhong, R., Liu, D., & Lu, W. (2017). A Physical Internet-enabled Building Information Modelling System for prefabricated construction. *International Journal of Computer Integrated Manufacturing (Print)*, 31, 349–361.

Chong, H., Lee, C.-Y., & Wang, X. (2017). A mixed review of the adoption of Building Information Modelling (BIM) for sustainability. *Journal of Cleaner Production*, 142, 4114- 4126.

Djuedja, J. F. T., Karray, M.-H., Foguem, B. K., Magniont, C., & Abanda, F. H. (2018). Interoperability Challenges in Building Information Modelling (BIM*). I-ESA*, 275-282.

Elghaish, F., Abrishami, S., Gaterell, M. & Wise, R. (2018). Integrating Dependent Material Planning Cycle into Building Information Management: A Building Information Managementbased Material Management Automation Framework. *World Academy of Science, Engineering and Technology International Journal of Structural and Construction Engineering*, 12 (3), : 253-258

Foster, L. L. (2008). Legal Issues and Risks Associated with Building Information Modelling Technology. (Unpublished Master's dissertation). University of Kansas.

Gourlis, G., & Kovacic, I. (2017). Building Information Modelling for analysis of energy efficient industrial buildings – A case study. *Renewable & Sustainable Energy Reviews*, 68, 953-963.

Harrison, C. & Thurnell, D. (2015). BIM Implementation in a New Zealand Consulting Quantity Surveying practice. *International Journal of Construction Supply Chain Management*, 5(1), 1-15. DOI:10.14424/ijcscm501015-01-15

Ibrahim, A.Q. S., & Ahmad, T. H. (2020), Understanding the Conceptual of Building Information Modeling: A Literature Review. *International Journal of Civil Engineering and Technology*, 11(1), 165-171.

Jon, S. (2022). *RICS Digitalisation in Construction report*. ISBN 978 1 78321 470 9

Keegan, C. J. (2010). Building Information Modelling in Support of Spatial Planning and Renovation in Colleges and Universities. WPI electronic theses and dissertations. retrieved from http://www.wpi.edu/pubs/etd/

Liu, H., Lu, M., & Al-Hussein, M. (2014). Bim-Based Integrated Framework for Detailed Cost Estimation and Schedule Planning of Construction Projects. In Proceedings of the 31st International Symposium on Automation and Robotics in Construction and Mining (ISARC).

Nasila, M., & Cloete, C. (2018). Adoption of Building Information Modelling in the construction industry in Kenya. *Acta Structilia*, 25(2), 1-38.

Nechyporchuk, Y., & Bašková, R. (2020). The level of BIM awareness of students in faculty of civil engineering. *In EDULEARN20 Proceedings*, 2610-2616. IATED

Noor, A.A.I, Robin, D., Scott, B. & Robert, O. (2016). A Review of BIM Capabilities for Quantity Surveying Practice. *MATEC Web of Conferences 66, 00042 (2016) DOI:10.1051/matecconf/20166, IBCC.*

Oke A. E., Timothy I. O. & Olaniyi A. I. (2010). Perception of Construction Professionals to the Performance of Nigerian Quantity Surveyors. *Journal of Building Performance*. 1(1), 64-72.

Oladiran, O. J., Simeon, D. R., &Anyira, S. O. (2022). Building Information Modelling (BIM): Drivers, barriers and socio-economic benefits. *Covenant Journal of Research in the Built Environment*. 13-23.

Olawumi, T. O., & Chan, D. W. M. (2019). Development of a benchmarking model for BIM implementation in developing countries. *Benchmarking*, 26 (4) , 1210-1232 . https://doi.org/10.1108/BIJ-05-2018- 0138

Othman, M., Elbeltagi, E., Abdelshakor, M., & Ehab, A. (2022). Adopting the 3D BIM Coordination during the Early Design Stages in Egypt. Construction Research Congress 2022: Computer Applications, Automation, and Data Analytics - Selected Papers from Construction Research Congress 2022, 2-B(March), 12121222.

Popoola, O. Aluko O. O., & Omoyajowo, N. I. (2024) A Review of Adoption of Building Information Modelling (BIM) for the Nigerian Building and Construction Industry. *Journal of Civil Engineering Research & Technology*, 6(2), 1-6. SRC/JCERT-157. DOI: doi.org/10.47363/JCERT/2024(6)156

Rowlinson, S. (2017). Building information modelling, integrated project delivery and all that. *Construction Innovation*, 17(1), 45-49.

Samimpay, R. & Saghatforoush, E. (2020). Benefits of implementing building information modelling (BIM) in infrastructure projects. *Journal of Engineering, Project, and Production Management*, 10: 123-140.

Siew, R. (2015). Integrating sustainability into construction project portfolio management. *KSCE Journal of Civil Engineering*, 20, 101-108.

Silva, G. A., Warnakulasooriya, B. N. F., & Arachchige, B. (2016). Criteria for construction project success: A literature review. *In University of Sri Jayewardenepura, Sri Lanka, 13th International Conference on Business Management (ICBM)*. 697-717

Sinclair, D. (2012). BIM Overlay to the RIBA Outline Plan of Work. London, UK: Royal Institute of British Architects (RIBA).

Staub-French and Khanzode, A. (2007). 3D and 4D modelling for design and construction coordination: issues and lessons learned. *Electronic Journal of Information Technology in Construction*, (12); 381 – 407.

Succar, B. (2009). Building information modelling framework: A research and delivery foundation for industry stakeholders. *Automation in Construction*, 18, 357-375

Teicholz, Paul. (2014). BIM for lean design and construction: Reducing waste and enhancing value in the AEC industry. *John Wiley & Sons.*

Yin, X., Liu, H., Chen, Y., & Al-Hussein, M. (2019). Building informa tion modelling for off-site construction: Review and future directions. *Automation in Construction*, 101(2) , 7 2 9 1 . https://doi.org/10.1016/j.autcon.2019. 01.010

Zigurat. (2018). Introduction to BIM. Barcelona, Spain: Rafael Riera Lopez.

DEVELOPMENT OF COMPUTER NUMERICAL CONTROL WOODWORKING MACHINES CONTENT FOR INTEGRATION INTO NIGERIA CERTIFICATE IN EDUCATION (TECHNICAL) CURRICULUM

Hassan S.,[1] Tadnum, Y. M.,[2] Saulawa, B. U.,[3] Hamza, S.,[4] Angulu, H.,[5] and Chedi, J. M.,[6]

[1, 3,4, 5 & 6]Faculty of Technology Education,
Abubakar Tafawa Balewa University Bauchi, Nigeria
[2]School of Vocational and Technical Education
Abubakar Tatari Ali Polytechnic Bauchi
Corresponding Author: *hsanusi@atbu.edu,ng (Tel: +2348085265490)

Abstract
The study was conducted to develop Computer Numerical Control woodworking machines content for integration into Nigeria Certificate in Education (Technical) Curriculum. Two research questions and three null hypotheses guided the study. The study adopted a modified version of research and development (R&D) design. Specifically, the Febriana's (2016) modified version of R&D was adopted to guide the research. The research was conducted in North-East Nigeria. The population of the study was 26 respondents, which consists of all the 18 woodwork lecturers and 8 instructors. Total Population Sampling (TPS) was used. A structured questionnaire with a 5-point rating scale was adapted and used for data collection in the study. The validity of the instrument was determined by three experts. To ensure the reliability of the instrument a pilot test was conducted in Kano State, Nigeria. The reliability coefficient obtained was 0.89. The data obtained was analyzed with the aid of Statistical Package of Social Science (SPSS). Mean was used to answer the research questions while t-test was used to test the null hypotheses at 0.05 level of significant. The study found that ten objectives were relevant for inclusion in CNC woodworking machines content, seven methods of teaching and seven materials, tools and equipment were relevant for teaching CNC woodworking machines content. Likewise, all the three null hypotheses were retained. It was, therefore, recommended among others that the NCCE should review the NCE **(**Technical**)** curriculum in order to integrate the CNC woodworking machines content.
Keywords: Curriculum, Computer Numerical Control Woodworking Machines, Content, Nigeria Certificate in Education (Technical)

Introduction
Technical Vocational Education and Training (TVET) has been described in so many ways that showcased that it is important type of education in the socio-economic development of a nation. TVTE holds the key to training the skilled and entrepreneurial workforce needed for the changing technological workforce (Afeti, 2010). The Federal Government of Nigeria in its National Policy on Education (FGN, 2013) defined TVET as the comprehensive term referring to those aspects of the educational process involving in addition to general education, the study of technologies and related science and the acquisition of practical skills, attitudes, understanding and knowledge relating to occupations in various aspects of economic and societal life. In Nigeria TVET incorporates the training of artisans, craftsmen/women, as well as highly skilled technician and technologists.

Nigeria Certificate of Education (Technical) is one of the key aspects of TVET that is offered in Colleges of Education (Technical) and Polytechnics. The program is a teacher education program for preparing teachers who will be sound in pedagogy and equipped with relevant skills to teach technical subjects as well as work in the industrial or private sectors of economy. The philosophy of the program as spelled out in the National Commission for

Colleges of Education minimum standards (NCCE, 2020) is to provide technical teachers with the intellectual and professional background adequate for teaching technical subjects and to make them adaptable to any changing situation in technological development not only in the country but also in the world at large.

The curriculum of the program is largely focused on vocational courses such as automobile, building, electrical/electronic, metalwork and woodwork. However, these courses do not cover modern technologies advancement such as Computer Numerical Control machines (CNC). CNC is a manufacturing technology in the 21st century which brought about changes from the manual traditional machining process to a new machining process which is more suitable for precision machining of hard and brittle materials (Jan, 2010). CNC woodworking machines are revolutionizing the woodworking industry by providing unparalleled precision, speed, and efficiency. The machines are designed to perform various tasks, including cutting, drilling, shaping, and finishing, with minimal human intervention. CNC woodworking is a computer-control device that uses specialized software to precisely cut, shape, and carve wood materials.

The lack of content related CNC woodworking machines being captured in the curriculum is resulted in a significant skills gap, where NCE (Technical) woodwork graduates are ill-prepared to engage with rapidly emerging technologies such as CNC. This skills gap is particularly problematic as it affects the quality of education and ability of future educators to train students in this critical. Zarewa *et al.*, (2023) noted that the inability of carpentry and joinery teachers operate the CNC in delivering practical lesson could be attribute to inadequate experiences or competencies in using CNC. To address this problem, there is need to develop content that will focus on CNC woodworking machines. It is against this background that this research intended to develop CNC woodworking machines content for integration into NCE (Technical) curriculum.

Research Questions

The following research questions guided the study:

1. What are the relevant objectives for inclusion in CNC woodworking machines content?
2. What are the relevant methods of teaching CNC woodworking machines content?
3. What are the relevant materials, tools and equipment for teaching CNC woodworking machines content?
4. What is the validity of the developed CNC woodworking machines content for integration into NCE **(**Technical**)** curriculum?

Hypotheses

The following null hypotheses were tested at 0.05 level of significant:

$H_0$1: There is no significant difference in the mean responses of woodwork lecturers and instructors on the relevant objectives for inclusion in CNC woodworking machines content

$H_0$2: There is no significant difference in the mean responses of woodwork lecturers and instructors on the relevant methods of teaching CNC woodworking machines content

$H_0$3: There is no significant difference in the mean responses of woodwork lecturers and instructors on the relevant materials, tools and equipment for teaching CNC woodworking machines content

Methodology

A modified version of research and development (R&D) design was adopted to guide the study. Specifically, the study adopted Febriana's (2016) modified version of R&D. The steps in the modified version are preliminary study; development; and validation. The modified version is simplified to be used in developing a pedagogical material for student-teacher. Hence, the design is suitable for the present study. The study was conducted in

North-East Zone, Nigeria. The zone is located within the geographical boundary of latitudes of 6,260 East and 4,920 North East of the equator. It occupies a total land area of 103,639km^2 (Atlas, world map, cited in Aminu & Apagu, 2016). The zone comprised Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe States.

The population for the study consists of all 26 the woodwork lecturers and instructors in the institutions offering NCE (Technical) in North-East Nigeria.

Table 1: Population Distribution of the Study

S/N	Institutions	States	No. of Lecturers	No. of Instructors	Total
1.	College of Education Hong	Adamawa	02	01	03
2.	Abubakar Tatari Ali Polytechnic Bauchi	Bauchi	02	01	03
3.	Aminu Saleh College of Education Azare	Bauchi	01	01	02
4.	Federal College of Education (Technical) Gombe	Gombe	06	03	09
5.	Federal College of Education (Technical) Potiskum	Yobe	07	02	09
	Total		**18**	**08**	**26**

Total Population Sampling (TPS) was used to select all the woodwork lecturers and instructors in all the institutions offering NCE (Technical) in North-East Nigeria. According Kothari (2004) TPS is one of the purposive sampling techniques that involve examining the whole population if found small and manageable that has a particular set of characteristics (e.g. specific attributes/traits, experience, knowledge, skills exposure to an event, etc.).

A structured questionnaire titled "Computer Numerical Control Woodworking Machines Content Questionnaire" (CNCWMCQ) was adapted and used to collect data for the study. The questionnaire had a 5-point rating response scale of Highly Relevant, Relevant, Moderately Relevant, Not Relevant, and Highly Not Relevant with corresponding values of 5, 4, 3, 2 and 1 respectively.

The instrument was validated by three experts from the Faculty of Technology Education, Abubakar Tafawa Balewa University Bauchi. To ensure the reliability of the instrument a pilot test was conducted in Kano State, Nigeria. Cronbach's Alpha was used to determine the internal consistency of the instrument and the reliability coefficient obtained was 0.89.

The service of five trained research assistants was employed to assist the researchers in the distribution and retrieval of the research instrument, a spot approach was used for the data collection. The data obtained was analyzed with aid of Statistical Package of Social Science (SPSS). Mean was used to answer the research questions while t-test was used to test the null hypotheses at 0.05 level of significant. The mean scores were interpreted based on the true class limit of real whole numbers: 4.50 – 5.00 = Highly Relevant, 3.50 – 4.49 = Relevant, 2.50 – 3.49 = Moderately Relevant, 1.50 – 2.49 = Not Relevant, and 0.50 – 1.49 = Highly Not Relevant and P-value greater than the, significant level of 0.05 was considered not significant difference in the mean responses.

Results

Research Question 1: What are the relevant objectives for inclusion in CNC woodworking machines content?

Table 2 revealed that all the ten objectives have average mean responses between 3.50 and 3.74. This indicated that all the objectives are relevant for inclusion in CNC woodworking machines content.

Table 2: Mean Responses of Woodwork Lecturers and Instructors on Relevant Objectives for Inclusion in CNC Woodworking Machines Content (N_1=18, N_2=8, N_T=26)

S/N	Objectives, the students should be able to:	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_\wedge$	Remarks
1.	Explain the basic principles of CNC machines.	3.40	3.67	3.54	Relevant
2.	Explain the CNC programming concepts	3.77	3.42	3.56	Relevant
3.	Programming formatting - reasons and program formats.	3.54	3.45	3.50	Relevant
4.	Method of programming - manual, conversational, CAM system and developing programs.	3.38	3.65	3.52	Relevant
5.	Describe the basic machining practices	3.47	3.91	3.69	Relevant
6.	Identify various CNC machine components.	3.57	3.45	3.51	Relevant
7.	Explain common programmable functions of CNC machines.	3.70	3.94	3.82	Relevant
8.	Explain operation modes (manual and manual data input)	3.82	3.42	3.62	Relevant
9.	Explain various sequence of CNC machines operation	3.82	3.42	3.62	Relevant
10.	Safe uses of CNC in machining – safety considerations for various CNC machine operations.	3.36	4.11	3.74	Relevant

Keys: N1 = Number Woodwork Lecturers, N_2 = Number of Instructors, N_1= Total Number of Respondents, $\bar{X}_1$ = Mean of Woodwork Lecturers, $\bar{X}_2$ = Mean of Instructors, $\bar{X}_\wedge$ = Average Mean of Woodwork Lecturers and Instructors.

Research Question 2: What are the relevant methods of teaching CNC woodworking machines content?

Table 3 indicated that all the seven methods of teaching have average mean responses between 3.50 and 3.76. This implied that all the methods of teaching are relevant for teaching CNC woodworking machines content.

Table 3: Mean Responses of Woodwork Lecturers and Instructors on the Relevant Methods of Teaching CNC Woodworking Machines Content (N_1=18, N_2=8, N_T=26)

S/N	Methods of Teaching	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_\wedge$	Remarks
11.	Activity Approach	3.58	3.62	3.60	Relevant
12.	Discussion	3.77	3.42	3.60	Relevant
12.	Demonstration	3.54	3.45	3.50	Relevant
14.	Laboratory work/practical	3.38	3.65	3.52	Relevant
15.	Peer Tutoring	3.64	3.38	3.51	Relevant
16.	Project Based	3.64	3.44	3.54	Relevant
17.	Simulation	3.82	3.70	3.76	Relevant

Research Question 3: What are the relevant materials, tools and equipment for teaching CNC woodworking machines content?

Table 4 showed that all the seven materials, tools and equipment have average mean responses between 3.50 and 3.76. This implied that all the materials, tools and equipment are relevant for teaching CNC woodworking machines content.

Table 4: Mean Responses of Woodwork Lecturers and Instructors on Relevant Materials, Tools and Equipment for Teaching CNC Woodworking Machines Content (N_1=18, N_2=8, N_T=26)

S/N	Materials, Tools and Equipment	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_\wedge$	Remarks
18.	CAD/CAM Software	3.70	3.40	3.55	Relevant
19.	CNC Machine Manuals	3.70	3.80	3.75	Relevant
20.	CNC Programming Software	3.50	3.50	3.50	Relevant
21.	Referencing Charts	3.54	3.45	3.50	Relevant
22.	Simulation Software	3.64	3.38	3.51	Relevant
23.	Troubleshooting Guides	3.64	3.44	3.54	Relevant
24.	Video Tutorials	3.82	3.70	3.76	Relevant

Hypotheses Testing

$H_0$1: There is no significant difference in the mean responses of woodwork lecturers and instructors on the relevant objectives for inclusion in CNC woodworking machines content.

The result presented in table 6 revealed that the difference in the mean responses of woodwork lecturers and instructors on the relevant objectives for inclusion in CNC woodworking machines content is not significant as the p-value obtained (.643) is greater than 0.05 significant level. Therefore, the null hypothesis is retained.

Table 6: t-test Analysis for Difference between the Mean Responses of Woodwork Lecturers and Instructors on the Relevant Objectives for Inclusion in CNC Woodworking Machines Content

Respondents	N	$\bar{X}$	df	t-value	p-value	Decision
Woodwork Lecturers	18	3.58				
			24	.585	.643	Retained
Instructors	8	3.64				

P<0.05=Significant, P>0.05=Not Significant

$H_0$2: There is no significant difference in the mean responses of woodwork lecturers and instructors on the relevant methods of teaching CNC woodworking machines content

The result presented in table 7 showed that the difference in the mean responses of woodwork lecturers and instructors on the relevant methods of teaching CNC woodworking machines content is not significant as the p-value obtained (.410) is greater than 0.05 significant level. Thus, the null hypothesis is retained.

Table 7: t-test Analysis for Difference between the Mean Responses of Woodwork Lecturers and Instructors on the Relevant Methods of Teaching CNC Woodworking Machines Content

Respondents	N	$\bar{X}$	df	t-value	p-value	Decision
Woodwork Lecturers	18	3.62				
			24	.340	.410	Retained
Instructors	8	3.52				

P<0.05=Significant, P>0.05=Not Significant

$H_0$3: There is no significant difference in the mean responses of woodwork lecturers and instructors on the relevant materials, tools and equipment for teaching CNC woodworking machines content.

The result presented in table 8 indicated that the difference in the mean responses of woodwork lecturers and instructors on the relevant materials, tools and equipment for teaching CNC woodworking machines content is not significant as the p-value obtained (. 429) is greater than 0.05 significant level. Consequently, the null hypothesis is retained.

Table 8: t-test Analysis for Difference between the Mean Responses of Woodwork Lecturers and Instructors on the Relevant Materials, Tools and Equipment for Teaching CNC Woodworking Machines Content

Respondents	N	$\bar{X}$	df	t-value	p-value	Decision
Woodwork Lecturers	18	3.67				
			24	.83	. 429	Retained
Instructors	8	3.52				

P<0.05=Significant, P>0.05=Not Significant

Findings of the Study

The following are finding of the study:

1. Ten objectives were relevant for inclusion in CNC woodworking machines content and the difference in the mean responses of woodwork lecturers and instructors on the relevant objectives for inclusion in CNC woodworking machines content is not significant.
2. Seven methods of teaching were relevant for teaching CNC woodworking machines content and the difference in the mean responses of woodwork lecturers and instructors on the relevant methods of teaching CNC woodworking machines content is not significant.
3. Seven materials, tools and equipment were relevant for teaching CNC woodworking machines content and the difference in the mean responses of woodwork lecturers and instructors on the relevant materials, tools and equipment for teaching CNC woodworking machines content is not significant.

Discussion of Findings

The finding of the study revealed that ten objectives were relevant for inclusion in CNC woodworking machines content. It further showed that the difference in the mean responses of woodwork lecturers and instructors on the relevant objectives for inclusion in CNC woodworking machines content is not significant. Adamu et al. (2023) in a study carried to develop automotive computer control systems service and repair (ACCSSAR) course for university students in Nigeria, 11 objectives were found relevant to be included and there was no significant difference in the mean ratings of lecturers of automobile technology education and supervisors/managers of automobile workshops on the objectives of ACCSSAR course. The findings of the above authors gave credibility to findings of this study. Consequently, the ten objectives were included in CNC woodworking machines content for integration into NCE (Technical) Curriculum.

The finding of the study also revealed that seven methods of teaching were found relevant for teaching CNC woodworking machines content and the difference in the mean responses of woodwork lecturers and instructors on the relevant methods of teaching CNC woodworking machines content is not significant. Muhammad (2023) in a study conducted to develop CCTV and SPVT course to be integrated into Nigeria Certificate in Education (Technical) Programme, 13 methods of teaching were found appropriate for inclusion in CCTV and SPVT course and there is no statistically significant difference among the mean responses of Basic Technology Electrical and Electronic Technology Lecturers and SPVT industrial experts on the appropriate methods of teaching for inclusion in CCTV and SPVT course. The findings of the above authors gave credibility to findings of this study. Therefore, the seven methods of teaching were included in CNC woodworking machines content for integration into NCE (Technical) Curriculum.

The finding of the study also revealed that seven materials, tools and equipment were found relevant for teaching CNC woodworking machines content and the difference in the mean responses of woodwork lecturers and instructors on the relevant materials, tools and equipment for teaching CNC woodworking machines content is not significant. In his study, Muhammad (2023), found 23 appropriate teaching materials, tools and equipment for inclusion in CCTV and SPVT course and there is no statistically significant difference among the mean responses of basic Technology Electrical and Electronic Technology Lecturers and SPVT industrial experts on the appropriate teaching materials, tools and equipment for inclusion in CCTV and SPVT course. Consequently, the seven materials, tools and equipment were included in CNC woodworking machines content for integration into NCE (Technical) Curriculum.

Conclusion

The study was conducted to develop CNC woodworking machines content for integration into NCE (Technical) Curriculum. The findings of this study have resulted in a developed CNC woodworking machines content for integration into NCE (Technical) Curriculum that contains ten objectives, seven methods of teaching and seven materials, tools and equipment. If the content is integrated into NCE (Technical) curriculum, the students will graduate with hands-on experience in modern manufacturing technologies, prepare them for industrial demands and entrepreneurship opportunities, enhance the teaching of woodworking and design principle, encourage innovation, creativity, and problem-solving skills.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. The NCCE should review the NCE **(**Technical**)** curriculum in order to integrate the CNC woodworking machines content.
2. The woodwork lecturers and instructors should be retrained in order to teach the CNC woodworking machines content effectively.
3. Government should provide relevant materials, tools and equipment for teaching CNC woodworking machines content.

References

Adamu, A. S., Yalams, S. M, & Shuaibu, B. (2023). Development of automotive computer control systems services and repair (ACCSSAR) course for university students in Nigeria. In A. M. Hassan, H. R. Sa'i, A. S. Bappah, P.S. Williams, & N. N. Afaor (Eds) *Proceedings of the 36th Annual National Conference and Annual General Meeting of Technology Education Practitioners Association of Nigeria* (pp. 213-220) Lagos: Technology Education Practitioners Association of Nigeria (TEPAN).

Afeti, G. (2010). *Technical vocational education and training for industrialization.* Retreaved from http://www.arrforum.org/publication/occasional-paper/40/95-technical-andvocational-education-andtraing-for-industrialization.html.

Aminu, T. U. & Apagu, V. V., (2016). Development and standardization of an instrument for assessing performance of students in oxy-acetylene task operations at technical college level. *ATBU Journal of Science, Technology and Education*, *4* (1), 162- 173.

Bong, W. R. & Gall, M. D. (1983). *Educational research: An introduction.* Longman.

Febriana, R. (2016). Identifikasi komponen model pelatihan pedagoji untuk meningkatkan profesioanalitas calon guru kejura. *Jurnal Pendidikan Teknologi dan Kejuruan, 23*(1). 79-89.

Federal Republic of Nigeria (2013). *National Policy on Education* (6th Ed.). NERDC Press.

Jan, E. D. (2010). *Handbook on advanced design and manufacturing technologies*. http://books.google.com.ng.books

Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International (P) Limited, Publishers 4835/24, Ansari Road, Daryanganj, New Delhi – 110002 www.newagepublishers.com.

Muhammad, B. (2023). Development and validation of closed-circuit television and solar photovoltaic technology course for integration into Nigeria Certificate in Education (Technical) programme. Unpublished M. Tech. Ed. Thesis submitted to Postgraduate School. Federal University of Technology, Minna, Nigeria.

National Commission for Colleges of Education (2020). Minimum standards for NCE (2012 ed). NCCE.

Okoro, O. M., (2004). *A manuscript on evaluation in vocational and technical education*. Department of Vocational Teacher Education, University of Nigeria, Nsukka.

Ugodulunwa, C. A. (2018). *Fundamentals of educational measurement and evaluation*. Fab Educational Books.

Wheeler, D. K. (1971). *Curriculum process.* Hodder & Stoughton.

Zarewa, M. N., Hassan, A., Hussaini, L., & Habeeb, A. (2023). Competency needs of technical colleges carpentry and joinery teachers in the use of computer numerical control circular saw machine in Northwest, Nigeria. *Proceedings of the 9th Hybrid International Conference of School of Science and Technology Education (SSTE), Federal University Technology, Minna* Virtual Conference, Federal University of Technology Minna, Niger State, on 2nd to 6th October, 2023. Pp 57.

DEVELOPMENT OF BUILDING INFORMATION MODELLING COURSE CONTENT FOR INCLUSION IN BUILDING TECHNOLOGY MINIMUM STANDARD IN COLLEGES OF EDUCATION IN NIGERIA

Tijjani, Aminu[1] Dauda, I. [2], Kagara, A. B. [3], Okwori R. O. [4]
Department of Science and Technology Education[1],
Bayero University, Kano
Department of Industrial and Technology Education[234]
Federal University of Technology Minna
atchiroma81@gmail.com
08065283128

Abstract

The study developed Building Information Modelling course content for Inclusion in Building Technology Minimum Standard in Colleges of Education in Nigeria. The research design adopted for the study was a mixed method, comprising of both qualitative and quantitative methods of data collection. The total population of the study was 1394, comprising of 82 lecturers of building technology education, and 1312 industrial personnels. The industrial personnels were architects, builders, civil engineers and quantity surveyors in north-west, Nigeria. The sample size of the study was 389 respondents. Instruments used for data collection were 3D Building Information Modelling Questionnaire and interview interactive guide developed by the researcher, and were validated by three experts. The reliability coefficient of the instrument was obtained using Cronbach's alpha statistics and was found to be 0.93. Mean and standard deviation were used to answer the research questions, while null hypotheses were tested using z-test statistics at 0.05 level of significance. Findings of the study revealed that explanation of the fundamental concepts of BIM tools among all other items listed as the objectives of BIM tools with a grand mean of 3.42 and standard deviation of 0.63 were agreed by the respondents and included in the BIM course content. Graphisoft ArchiCAD and all the remaining items listed as the BIM tools with a grand mean of 3.19 and standard deviation of 0.74 were agreed by the respondents. The study also revealed that there was no significant difference between the mean responses of building industrial personnels and lecturers of building technology education on the BIM tools objectives and appropriate BIM tools for building modelling. Based on the findings, it was recommended that the National Commission for Colleges of Education (NCCE) should consider the inclusion of BIM tools course content in building technology education minimum standard so as to ensure the achievement of BIM tools objectives that will help in improving the quality of the programme as well as organizing hands on training workshop on BIM tools to their lecturers of building technology education programme so as to train them on how to use the tools for 3 dimensional (3D) drawing.

Introduction

In present days, Building Information Modelling (BIM) has been used in the construction industry and is receiving an overwhelming attention more especially by construction professionals such as Architects, Builders, Civil Engineers and Quantity Surveyors. BIM is an intelligent software that architects, engineers and contractors use to collaborate on a planning, design, construction and operation of building (Sarah, 2022). It is one of the simulation prototyping technology and workflow that has now become a revolutionary development reshaping and benefiting Architecture, Engineering, and Construction (AEC) industry. According to Muhammad *et al.* (2020), the overwhelmed technology element of BIM has benefited its users in visualizing and investigating what is to be constructed in a

computer simulated environment. It also helps in identifying any potential planning, design, construction, operational, or maintenance issues regarding the proposed building. The collaborative use of BIM in the AEC industry more especially 3D BIM has resulted in completing various construction projects with higher quality, appropriate timing and greater customer satisfaction.

Three Dimensional BIM (3D BIM) is one of the most important BIM tools used for drawing building project in three dimensions (x, y, z). The tool has immense benefits not only to the construction industries but also educational institutions of learning. According to Agirbas (2020) the tool can help students understand the complex geometry of any building through 3D visualization which can facilitate the students drawing of building plan that can be visualized using a 3D virtual model that incorporates all architectural element features and metadata. Design errors can be eliminated and design quality can be improved. In addition, data about the building's lifecycle can be handled (Doan *et al.*, 2020; Chiu and Lai, 2020; Enhassi, *et al.*, 2018). In order to enjoy these benefits, there is a need for the integration of BIM course content in minimum standard of colleges of education in Nigeria.

Colleges of education in Nigeria are one of the tertiary educational institutions established by law to render professional training for the production of qualified classroom teachers. These institutions play significant roles in the production of teachers for both basic and senior secondary and technical schools' education. Nwite and Nwuche (2016) revealed that, **c**olleges of education are specially designed to develop, pursue and improve regular and liberal courses of study for the training of various categories of teachers and promote the advancement of learning and educational research. Colleges of education in Nigeria are either regular, special or technical (Ezeukwu, 2016). Students of technical education in the colleges of education are not only trained to teach at secondary schools but are also equipped with the knowledge, attitudes and skills that enables them to have an intelligent understanding of their environment, in addition to working in the industry as technicians, a need which necessitate them to acquire knowledge and skills in BIM. Their acquiring BIM skills will help them to prepare technical school students they will later train for the job ahead. Nevertheless, the depth and relevance of the skills invariably depend on the curriculum used for the programme. The technical education programmes including building technology education in colleges of education are designed to assist learners in developing scientific knowledge and most especially acquiring skills that are beneficial to the society.

Specifically, the Building Technology Education programme was designed to prepare students with the technical skills, techniques on how to use tools and raw materials needed for the design, construction and maintenance of buildings, being it residential, commercial, industrial among numerous others. Building technology borders on how technical and vocational education can be used to improve the quality of life of the individual and the society in general. The National Commission for Colleges of Education (NCCE, 2012) stated the aim of building technology education in colleges of education is to produce teachers with the technical and instructional competencies to practice in educational field to impart knowledge, skills and attitude to learners as well as to practice in construction industry as technicians. According to Usman *et al.* (2020), the performance of graduates of building technology from colleges of education in Nigeria is unfortunate and is not reflecting the realization of the aim of which the course was established. Therefore, there is a need to develop a minimum standard with more useful and needful contents that will prepare students to cope with the explosive technological advancement.

Minimum standards according to NCCE (2012) is defined as the minimum the teacher educators should know and be able to do as well as their expected minimum dispositions towards their work if they must remain/progress in their career. Nwanna (2005) sees the concept of minimum education standard as characteristics or attributes of educational

system, which are adjudged, by the authority as adequate or acceptable or desirable for good running of the system. However, for the minimum standard of any programme to fit into the dynamic changes and needs of the society, it needs to be revisited and reviewed from time to time for improvement. Anaele and Okoro (2014) stated that building technology education minimum standard in Colleges of Education (Technical) lacks the essential rudiments of technological innovations. Building drawing and introduction to computer aided design that are currently in the minimum standard of building technology education are becoming obsolete, as such students who were trained to work with such technologies were finding it difficult to efficiently compete with their counterpart from other field of construction due to non-inclusion of new course contents such as BIM content in the minimum standard of building technology education. According to Nwanna (2005) the concept of minimum standard finds expression in virtually every aspect of education such as objectives-what to be achieved. Therefore, in order to develop new course contents and integrate it into the minimum standard, it is essential to first identify the objectives of the course.

Course objectives according to Charlotte Center for Teaching and Learning (2023) specify a behavior, skill, or action that a student can demonstrate after achieving mastery of the objective. As such, objectives need to be written in such ways that are measurable by some sort of assessment. It is specific and serves as overall frame of reference for developing a curricular. Sharif and Ulil-Amor (2022) stated that, the main objective of the BIM course is to orient students with basic understanding, principles and techniques of developing 3D virtual models and related construction documents with BIM tools. In an effort to finding the appropriate objectives of the BIM tools to be included in the course contents, it is essential to identify the appropriate BIM tools to be used in teaching students building drawing in 3D.

Building Information Modelling tools are the software designed and produced by software design companies such as Autodesk, Microsoft, Bentley among numerous others that helps in creating models and other architectural work. With the help of BIM tools, users can improve and increase productivity and efficiency in creating 3D drawings and models. The software also helps in enabling communication and collaboration between designers and clients. Zeynep and Fatemeh (2019) identified some of the BIM software used for building modelling presentation as Autodesk Revit architecture, Graphisoft ArchiCAD, Bentley Architecture and many more. The data within BIM software assist in extracting the various views from a building model.

To this end, the importance of developing BIM course content for building technology education cannot be overemphasized especially in the use of BIM tools to acquire relevant skills that will ensure the employability of building technology education graduates in the modern world of technology, hence the need to carry out a study on the BIM course contents for Inclusion in building technology minimum standard in colleges of education, in Nigeria.

Statement of the Problem

Despite the world digital transformation from drawing manually to using CAD and now BIM, yet, inadequacy of 3D BIM software and lack of training in using the software in the minimum standard of building technology in colleges of education has made lecturers to be using manual method of drawing to teach their students, the method which is now faded. Clients and building regulatory agencies prefer drawings done with BIM tools such as ArchiCAD, Revit architecture, Chief architecture among numerous others. The National Building Code (NBC, 2006) clearly outlined the responsibilities of a builder which include certifying the proper management and production process of building work and confirm that the quality is as designed and specified in the approved documents. Therefore, use of BIM tools is necessary for all building technology education students most especially if they are to comply with the above outlined responsibilities. Lack of its integration by curriculum

planners/regulatory agencies has made lecturers lacking in the use of the BIM tools. Prescilla *et al.* (2022) stated that, difficulties of integrating different curriculum areas to realize the multidisciplinary aspect of BIM and lack of qualified lecturers to teach BIM are some of the factors responsible for BIM integration into the curriculum. One of the objectives of technical education outlined by National Commission for Colleges of Education (NCCE, 2012) minimum standard is to produce qualified technical teachers motivated to start the so much desired revolution of technological development right from the Nigerian Schools, it however seems that lack of introducing modern courses like BIM in the programme of building technology education may defeat this objective. Based on the foregoing therefore, the study was designed to develop BIM Course contents for inclusion in building technology minimum standard in colleges of education in Nigeria.

Purpose of the Study

The study aim at developing building information modeling course contents for inclusion in building technology minimum standard in colleges of education in Nigeria.Specifically, the objectives of the study are to:

1. Determine the objectives of BIM tools course content for inclusion in building technology education minimum standard in colleges of education in Nigeria.
2. Determine the appropriate BIM tools content for inclusion in building technology education minimum standard in colleges of education in Nigeria

Research Questions

The following research questions were raised in line with the stated objectives to guide the study:

1. What are the objectives of BIM tools course content for inclusion in building technology education minimum standard in colleges of education in Nigeria?
2. What are the appropriate BIM tools content for inclusion in building technology education minimum standard in colleges of education in Nigeria?

Hypotheses

The following null hypothesis is developed to guide the study and will be tested for significance at 0.05 level.

Ho1: There is no significant difference in the mean responses of industrial personnel and lecturers of building technology education on the BIM tools objectives content for inclusion in building technology education minimum standard in colleges of education in Nigeria.

Ho2: There is no significant difference in the mean responses of industrial personnel and lecturers of building technology education on the appropriate BIM tools content for inclusion in building technology education minimum standard in colleges of education in Nigeria.

Methodology

The research adopted a mixed-method research design, comprising of interview and survey research. Specifically, the type of mixed method used for the study was exploratory sequential technique. This technique according to Edmonds and Kennedy (2017) is a progressive strategy that is used anytime that quantitative results are augmented by qualitative data. As a result, quantitative data analyses explain the qualitative results in succession. Numerous projects characterized by novel instrument creation choose this method as it enables scholar to construct the instrument using qualitative information and afterwards verify it quantitatively. One of the advantages of this method is that it explores a concept before validating it, allowing for greater versatility in discovering novel ideas

offered by the qualitative approach. The researcher used three out of 10 steps of R & D in developing the course content, which include research and information collection stage, development stage and validation stage. This was in line with the Chalong *et al.* (2013) who stated that, when using the "Ten-Step Model", the process may or may not include all the steps, may begin or end at any of the steps. The area used for conducting this research study covered seven North-West states in Nigeria, which include Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, and Zamfara. The population of the study was 1394 respondents. The respondents comprise of 1312 industrial personnels made up of 112 Architects, 240 Builders, 582 Engineers and 378 Quantity Surveyors working with industries. The sample size for the study was 389, comprising of all the 82 lecturers of building technology education in colleges of education, polytechnics and universities offering the programme and 307 sampled industrial personnels. The instruments used for data collection was 3D Building Information Modelling Course Contents Questionnaire (3DBIMCCQ) and Interview Interactive Guide for Industrial Personnels and Building Technology Education Lecturers in the Academia (I^2GIPBTELA)". The information obtained from the interview was transcribed, coded and used in improving the 3D BIM course content Questionnaire which was used in collecting data from all the respondents for the purpose of data analysis. The two instruments undergone face validation for content and construct by three experts. To establish the reliability of the 3D Building Information Modelling Course Contents Questionnaire, a pilot test was conducted on 36 industrial personnels from construction firms in Minna, Niger state. In addition, five, lecturers from Niger state college of education were used. This made a total population used for pilot testing as 41, which was greater than 10% of the total sampled population. Connelly (2018) stated that a pilot study sample should be 10% of the sampled projected for the larger parent study. The coefficient of internal consistency of the instrument was found to be 0.93 using cronbach's alpha statistics. Cronbach alpha according to Keith (2018) is widely used by authors in science education to represent the reliability, or the internal consistency of an instrument in relation to a particular sample or subsample of a population. Means and standard deviations were used to answer the research questions. In taking the decision from the analyze data using mean and standard deviation, the upper and the lower limits known as the real limit of numbers was used to determine the agreement level of the items in each research question. Z-test statistics was used to test the null hypothesis at 0.05 level of significance.

Result

The result of analysis of data are presented in line with the research questions and hypotheses that guided the study.

Research Question 1: What are the appropriate BIM tools objectives content for inclusion in building technology education minimum standard in Nigeria?

Table 4.1: Mean and Standard Deviation of respondents on the appropriate BIM tools objectives content for inclusion in building technology education minimum standard in Nigeria

S/No	BIM tools Objectives Content	$\bar{x}_1$	SD_1	$\bar{x}_2$	SD_2	$\bar{x}_A$	SD_A	Remark
		N_1=279		N_2=73		N_T=352		
1.	Explain the fundamental concepts of BIM tools	3.68	0.47	3.56	0.60	3.62	0.53	Strongly Agreed
2.	Correctly perform template setting for 3D modelling	3.66	0.53	3.38	0.59	3.52	0.56	Strongly Agreed
3.	Identify the right tools for 3D drawing	3.62	0.51	3.40	0.59	3.51	0.55	Strongly Agreed
4.	Exhibit competency in utilizing 3D drawing software library	3.48	0.51	3.52	0.53	3.50	0.52	Strongly Agreed

5.	Demonstrate proficiency in drawing accurate 3D floor plan of least two storey building using the software	3.47	0.66	3.48	0.60	3.47	0.63	Agreed
6.	Develop the capacity to design building interior	3.42	0.66	3.30	0.62	3.36	0.64	Agreed
7.	Successfully use the software to plan building services	3.48	0.56	3.22	0.71	3.35	0.64	Agreed
8.	Landscape building and its surrounding using the software	3.46	0.56	3.23	0.77	3.34	0.67	Agreed
9.	Be able to add foreground and background to the building	3.25	0.65	3.19	0.72	3.22	0.68	Agreed
10.	Demonstrate ability in generating building perspective views	3.39	0.61	3.27	0.71	3.33	0.66	Agreed
11.	Perform rendering of 3D building model	3.49	0.57	3.42	0.60	3.46	0.58	Agreed
12.	Correctly draw building layout	3.42	0.61	3.33	0.82	3.37	0.71	Agreed
13.	Develop ability to save and publish the complete drawing using a designated format	3.62	0.58	3.37	0.74	3.49	0.66	Agreed
14.	Demonstrate ability to upload or access BIM drawings to an online server for sharing with others	3.47	0.61	3.29	0.75	3.38	0.68	Agreed
15.	Effectively undertake 3D BIM base case studies	3.43	0.59	3.23	0.74	3.33	0.66	Agreed
	Grand Means	**3.49**	**0.58**	**3.35**	**0.67**	**3.42**	**0.63**	**Agreed**

N_1, $\bar{x}_1$, SD_1 = number, mean and standard of building industrial personnel, N_2, $\bar{x}_2$, SD_2 = number, mean and standard deviation of building technology education lecturers, and N_T, $\bar{x}_A$, SD_A = total number, average mean and average standard deviation of both building industrial personnels and building technology education lecturers

The results in Table 4.1 shows the mean and standard deviation of the responses of industrial personnels and building technology education lecturers on the BIM tools objectives. Items 1, 2, 3 and 4 had an average means between the range of 3.50 - 3.62, which fall within the real limit of 3.50 – 4.0. This means that the items were strongly agreed by the respondents. Likewise, all the remaining 11 items had their means ranging from 3.22 – 3.49, falling within the real limit of 2.5 – 3.49. This indicated that the respondents agreed on the items to also be included into the course content as the objectives of BIM tools. The average standard deviation of all the items 1 – 15 fall between the range of 0.52 and 0.71. This value shows that the standard deviation clustered around the mean and were indicating high level of mean validity.

4.2 Research Question 2: What are the appropriate BIM tools content for inclusion in building technology education minimum standard in Nigeria**?**

Table 4.2: Mean and Standard Deviation of respondents on the appropriate BIM tools content for inclusion in building technology education minimum standard in Nigeria

S/No	Appropriate BIM Tools Content	$\bar{x}_1$	SD_1	$\bar{x}_2$	SD_2	$\bar{x}_A$	SD_A	Remark
		N_1=279		N_2=73		N_T=352		
1.	Autodesk Revit Architecture	3.58	0.51	3.40	0.70	3.49	0.61	Agreed
2.	Chief Architect	3.33	0.61	3.16	0.80	3.25	0.71	Agreed
3.	Nemetschek Allplan Architecture	2.88	0.88	2.74	1.04	2.81	0.96	Agreed
4.	Graphisoft ArchiCAD	3.57	0.57	3.47	0.73	3.52	0.65	Strongly Agreed
5.	Gehry Tech. - Digital Project Designer	3.17	0.54	3.18	0.73	3.18	0.64	Agreed
6.	Nemetschek Vectorworks	3.09	0.77	3.04	0.77	3.07	0.77	Agreed

	Architect							
7.	4MSA IDEA Arch. Design (IntelliCAD)	3.19	0.81	3.21	0.76	3.20	0.78	Agreed
8.	Softtech Spirit	3.23	0.81	3.04	0.82	3.13	0.82	Agreed
9.	CADSoft Envisioneer	3.32	0.74	3.23	0.68	3.28	0.71	Agreed
10.	RhinoBIM (BETA)	3.31	0.80	3.16	0.71	3.24	0.75	Agreed
11.	Autodesk Vasari	3.28	0.76	3.26	0.69	3.27	0.73	Agreed
12.	CATIA	3.31	0.76	3.21	0.69	3.26	0.72	Agreed
13.	AutoCAD	3.53	0.64	3.40	0.76	3.46	0.70	Agreed
14.	Blender	3.09	0.78	3.00	0.91	3.04	0.85	Agreed
15.	Bricscad	3.08	0.72	3.14	0.67	3.11	0.69	Agreed
16.	Caddie	3.13	0.75	3.11	0.74	3.12	0.74	Agreed
17.	Cattia	3.14	0.76	2.99	0.72	3.06	0.74	Agreed
18.	DDS	3.09	0.81	2.89	0.97	2.99	0.89	Agreed
19.	Form Z	3.10	0.77	3.16	0.73	3.13	0.75	Agreed
20.	Houdini	3.06	0.66	2.96	0.90	3.01	0.78	Agreed
21.	Lightworks	3.17	0.76	3.11	0.70	3.14	0.73	Agreed
22.	Maya	3.10	0.73	2.82	0.73	2.96	0.73	Agreed
23.	Rhinoceros 3D	3.29	0.70	3.29	0.92	3.29	0.81	Agreed
24.	SolidWorks	3.30	0.58	3.23	0.77	3.27	0.68	Agreed
25.	3Ds Max	3.25	0.65	3.18	0.82	3.22	0.74	Agreed
26.	Cedro	3.24	0.77	2.97	0.67	3.11	0.72	Agreed
27.	Ashampoo 3D	3.25	0.78	3.11	0.89	3.18	0.84	Agreed
28.	Vector 3D	3.35	0.69	3.12	0.80	3.24	0.74	Agreed
29.	Lumion	3.40	0.69	3.07	0.69	3.23	0.69	Agreed
30.	Sketch up	3.47	0.54	3.25	0.78	3.36	0.66	Agreed
31.	BIMx	3.28	0.68	3.22	0.65	3.25	0.66	Agreed
32.	B Processor	3.28	0.70	3.16	0.76	3.22	0.73	Agreed
33.	BIM object	3.42	0.62	3.16	0.55	3.29	0.58	Agreed
	Grand Means	**3.25**	**0.71**	**3.13**	**0.77**	**3.19**	**0.74**	**Agreed**

Item 4 of Table 4.2 had an average mean of 3.52, fall within the real limit of 3.5 -4.0. This show that the item (Graphisoft ArchiCAD) was strongly agreed by the respondents as the BIM tools to be included into the BIM course content. All the remaining 32 items had an average means between the range of 2.81 and 3.49, falling within the real limit of 2.5 – 3.49, indicating that the respondents also agreed on all the remaining items to be included into BIM course content as tools for building modelling. On the other hand, the average standard deviation of all the items 1 – 33 fall between the range of 0.58 and 0.96. This was revealing how less dispersed the responses were from the mean.

Hypotheses one

Ho$_1$: There is no significant differences in the mean responses of industrial personnel and lecturers of building technology education on the BIM tools objectives content for inclusion in building technology education minimum standard in colleges of education in Nigeria.

Table 4.9: z-test Analysis of significant differences in the responses of industrial personnel and lecturers of building technology education on the objectives of BIM tools content

	Levene's Test for Equality of Variances		z-test for Equality of Means						
	F	Sig.	z	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal	4.796	.029	3.564	350	.000	.14114	.03960	.06326	.21902

variances assumed								
Equal variances not assumed			3.085	96.074	.003	.14114	.04575	.05033	.23195

Table 4.9 presents a summary of the z-test analysis of differences in the responses of building industrial personnels and lecturers of building technology on the BIM tools objectives content. The results of the analysis indicated that the significant criteria (sig.) of the Levens's test for equality of variance was 0.029 less than 0.05 confidence level. Therefore, the second raw z-statistics was used, indicating that equal variance not assumed. The z-value of 3.085 was compared with 0.05 level of significance. Since 3.085 was greater than 0.05, the hypothesis was therefore accepted. Hence there is no significant differences in the mean responses of building industrial personnel and lecturers of building technology education on the objectives of BIM tools content.

Ho2: There is no significant difference in the mean responses of industrial personnel and lecturers of building technology education on the appropriate BIM tools content for inclusion in building technology education minimum standard in colleges of education in Nigeria

Table 4.10: z-test Analysis of significant differences in the responses of industrial personnel and lecturers of building technology education on the appropriate BIM tools content

	Levene's Test for Equality of Variances		**z-test for Equality of Means**						
	F	**Sig.**	**z**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
								Lower	**Upper**
Equal variances assumed	.471	.493	2.260	350	.024	.11673	.05164	.01516	.21829
Equal variances not assumed			2.342	118.157	.021	.11673	.04983	.01805	.21541

The summary of z-test statistics in Table 4.10 show that the significant criteria (sig.) of the Levens's test for equality of variance was 0.493, greater than 0.05 confidence level, indicating equal assumption of variances. Therefore z-value of 2.260 was compared with 0.05 level of significance. Since 2.260 was greater than 0.05, the hypothesis was therefore accepted. Hence there is no significant differences in the mean responses of building industrial personnel and lecturers of building technology education on the appropriate BIM tools content.

Findings of the Study

Based on the analysis of data collected from the two groups of respondents comprising of building industrial personnels and building technology education lecturers, the following findings were made:

1. The respondents agreed on all the 15 items under the BIM tools objectives to be included into the course content. Objectives that top the list included the fundamental concepts of BIM tools, performing template setting for 3D modelling, identifying the

right tools for 3D drawing, exhibiting competency in utilizing 3D drawing software library, and developing ability to save and publish complete drawing using a designated format.

2. On the need to include tools for 3D modelling into the course content, the respondents agreed on all the 33 items. Those with high rating include; Graphisoft ArchiCAD, Autodesk Revit Architecture, AutoCAD (3D), Sketch up, Rhinoceros 3D and BIM object.
3. There was no significant difference in the mean responses of building industrial personnels and lecturers of building technology education on the objectives of BIM tools course content.
4. There was no significant difference in the mean responses of building industrial personnels and lecturers of building technology education on the appropriate BIM tools content for building modelling.

Discussion of Findings

The finding of the study on the BIM tools objectives which show the overwhelming agreement of all the 15 items by the respondents comprising the top-rated ones such as the fundamental concepts of BIM tools, performing template setting for 3D modelling, identifying the right tools for 3D drawing, exhibiting competency in utilizing 3D drawing software library, and developing ability to save and publish complete drawing using a designated format. Likewise, the analysis of the hypotheses tested revealed that there was no significant difference in the mean responses of building industrial personnel and lecturers of building technology education on the objectives of BIM tools content.

Based on the high level of agreement by the respondents on the need to include the BIM tools objectives into the course content, one can say that, developing a BIM course content with composition of objectives content is highly needed in the current era of technological development where the use of various computer application such as 3D BIM in teaching and learning process is inevitable if the students are to be equipped with the competencies needed in the area of building construction. This finding is supported by Sharif and Ulil-Amor (2022) who stated that, the main objective of the BIM course should be to orient students with basic understanding, principles and techniques of developing 3D virtual models and related construction documents with BIM tools, hence the need to include the objective of BIM tools into the course content. Objective is very vital in the design of a course content, as it gives clear vision of the area to be covered by the students in order to acquire the necessary skill needed in a course. According to Robecca *et al.* (2022), the design and redesign of a course is built around clear and measurable objectives that resulted in measurable benefits to students and also used to communicate the purpose of instruction, convey the expectations that the instructor has and by extension, academic field in terms of what students should know and be able to do after completing a course of study.

On the other side, the results of the hypotheses tested under the objectives content which indicated non-significant difference in the mean responses of building industrial personnels and building technology education lecturers who have similar view on the need to develop new course content with appropriate objectives in the area of BIM tools that could address the current challenges of non-integration of BIM related course into their curricular. This finding is in line with the view of Mohammed *et al.* (2023) who found non statistically significant difference in the mean rating of industrial personnel and electrical/electronic lecturers in colleges of education on the appropriate contents (covering objectives) of intelligent tutor for enhancing think-pair-share in repair and maintenance of electrical machines. The inclusion of the objectives into the course content and the non-statistically significant differences in the mean rating of the respondents were implying the need to come

up with a course content with clear objectives that could enable the students of building technology education have an understanding of using 3D BIM for building modelling.

Findings on the tools (Software) to be included into the course content revealed the agreement of all the 33 tools identified as the software to be used in teaching the BIM tools to the students by both building industrial personnels and lecturers of building technology education. Tools with higher rating includes: Graphisoft ArchiCAD, Autodesk Revit Architecture, AutoCAD (3D), Sketch up, Rhinoceros 3D and BIM object. On the analysis of the hypothesis, the mean responses of both building industrial personnels and lecturers of building technology education showed non statistically significant difference for tools to be included into the course content.

The implication of agreeing with all the tools to be used in teaching building technology education students in colleges of education was in the need to enrich the present minimum standard of building technology education programme with all the necessary tools that could lead them to acquiring of BIM tools skills, thereby satisfying the need of the industry and hastening the industrial and economic development of the country. This position commemorates with the findings of Nwankwo (2023) who stated that educational institutions should integrate BIM and digital construction tools into their academic curricula to equip aspiring professionals with hands-on experience and familiarity with tools that are increasingly becoming integral to modern construction practices. These BIM tools offers significant contribution in the drafting of buildings project in 3D. To support the finding of this research work on the tools to be included into the course content, Ricky *et al*. (2024) identified Revit Architecture as one of the qualified software to be used in construction planning.

On the non-significant difference in the mean rating of the two groups of respondents, it was clear that non-inclusion of those 3D software in the minimum standard of building technology education in colleges of education has been affecting the quality of the graduates and thereby reducing their chances of working in industry as construction professionals. This finding was in line with the submission of Wagbara and Chinyere (2025) who found non-significant difference between the mean ratings of lecturers and employers on the challenges to university-industry partnerships for achieving decent employment for students. This could mean that, integrating BIM tools into the course content is a welcome idea and hence need to be included.

Conclusion

Insufficiency of jobs to meet with the growing population, coupled with lack of employable skills have rendered many graduates of building technology education jobless. With construction industries playing vital role of providing employment opportunities to the graduates with updated skills, developing a Building Information Modelling (BIM) course content will help in tackling the challenge. This study therefore, developed BIM course content for inclusion in building technology minimum standard in colleges of education in Nigeria. Findings from the study revealed that the BIM tools objectives content involving fundamental concepts of BIM tools, performing template setting for 3D modelling, identifying the right tools for 3D modelling among others were included in the course content. BIM tools content involving Graphisoft ArchiCAD, Autodesk Revit Architecture, AutoCAD (3D), Sketch up, Rhinoceros 3D and BIM object among others were included in the course content. Based on these findings, it was concluded that integrating the BIM course content in the minimum standard of building technology in colleges of education would provide the students with the employment opportunities in the construction industries, which by extension could help in reducing the number of unemployed youths.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. The National Commission for Colleges of Education (NCCE) should consider the inclusion of BIM tools course content in building technology education minimum standard so as to ensure the achievement of BIM tools objectives that will help in improving the quality of the programme.
2. The National Commission for Colleges of Education (NCCE) should organize hands on training workshop on BIM tools to their lecturers of building technology education programme so as to train them on how to use the tools for teaching their students.

Reference

Anaele, E.O., & Okoro, C.E. (2014). Innovation in building technology and curriculum revision needs of COE (Technical) in Nigeria. *International Journal of Scientific Research.3*(2), 8179. DOI:10.15373/22778179/FEB2014/33

Chalong, T., Chonburi, T., Suthiporn, B., & Pathum, T.T (2013) *Curriculum development of vocational teacher education within the context of ASEAN integration process*. Regional Cooperation Platform for Vocational Teacher Education in Asia (RCP). 1-140. https://www.academia.edu/31669085

Charlotte Center for Teaching and Learning (2023). *Writing measurable course objectives*. https://teaching.charlotte.edu/teaching-guides/course-design/writing-measurable-course-objectives

Chiu, W.Y. B., Lai, J. H. K. (2020). Building information modelling for building services engineering: benefits, barriers and conducive measures. *Engineering, Construction and Architectural Management, 27*(9), 2221-2252. doi: 10.1108/ECAM-10-2018-0460

Connelly, (2018). Pilot studies. Medsurge nursing, 17(6), 411-2. www.scirp.org

Doan, D. T., GhaffarianHoseini, A., Naismith, N., Ghaffarianhoseini, A., Zhang, T. and Tookey, J. (2020). Examining critical perspectives on building information modelling (BIM) adoption in New Zealand. *Smart and Sustainable Built* Environment, 10(4), 594-615. doi: 10.1108/SASBE-04-2020-0043

Edmonds, W. A.; Kennedy, T. D. (2017). *Explanatory-sequential approach. In an applied guide to research designs*. Quantitative, Qualitative, and Mixed Methods; Edmonds. SAGE Publications, Inc.: Thousand Oaks, CA, USA.196–200

Enhassi, A., AbuHamra, L. A., and Alkilani, S. (2018). Studying the benefits of building information modeling (BIM) in architecture, engineering and construction (AEC) industry in the gaza strip, Jordan. *Journal of Civil Engineering*. *12*(1), 87-98.

Ezeukwu, F. I. (2016), *Managing students' hostel accommodation problems in colleges of education in Anambra and Enugu States*. *[*M. Ed project]. Department of Education, University of Nigeria, Nsukka.www.oer.unn.edu.ng/read/managing-students-hostel-accommodation-problems-in-polytechnics-in-anambra-and-enugu-state

Keith S.T. (2018). *The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education*.*48*(1), 1-24. doi: 10.1007/s11165-016-9602-2

Mohammed, A., Medugu, J. D., & Zambwa, J. (2023). Development of intelligent tutor for enhancing think-pairshare in learning of electrical machines in colleges of education

(technical) in north east, nigeria. *Integrity Journal of Education and Training, 7*(3). 64-73. https://doi.org/10.31248/IJET2023.189

Muhammad, N. M., Bassam, T., & Yazan-Isa, A.A. (2020). Building information modeling in enhancing the applying of knowledge areas in the architecture, engineering and construction industry, *Open Civil Engineering Journal*, *14*(1), 389. doi:10.2174/1874149502014010388

National Building Code (2006), *Federal Ministry of Housing and Urban Development*. Federal Republic of Nigeria. Interpak Books Pietermaritzburg.

National Commission for Colleges of Education (2012), *A Minimum Standard for Vocational and Technical Education,* Plot 829 Cadastral Zone AOI Ralph shodeinde Street. P.M.B, Garki Abuja.

Nwankwo U. (2023). *Identification and development of skills and competencies for bim and digital construction management in nigeria*. [Bachelor's thesis] University of Nigeria Nsukka, Degree Programme in Civil Engineering. Retrieved from DOI: 10.13140/RG.2.2.15815.06569

Nwanna O. P. N (2005). *Minimum standards and quality assurance in Polytechnic Education in Nigeria.* In Ezeh D. N. and Onyegegbu N. Edited, Knowledge generation and dissemination: Issues and challenges in Nigerian Universities. Enugu. Pearls and Gold

Nwite, O., &Nwuche, R.A. (2016), Evaluation of students' personnel services in Colleges of Education in Nigeria. *European American Journal, 4*(7), 82-98. https://eajournals.org/bje/vol-4-issue-7-july-2016/evaluation-students-personnel-services-colleges-education-nigeria/

Prescilla, P., Kan, F. K., & Wong, S. Y. (2022). Challenges and strategies to integrate building information modelling into quantity surveying programme in Sarawak higher education institutions, *Journal of Positive School Psychology*,*6*(3), 357–365. https://www.journalppw.com/index.php/jpsp/article/view/1398

Rebecca B. O., Melissa M. C., Scott F., & Michael C. R. (2022). Writing and using learning objectives. *CBE Life Eduaction, 12*(3), 1-10. https://doi.org/10.1187/cbe.22-04-0073

Ricky, J. S., Rezi, B. Y., & Adhi, P. (2024). *Skill Requirement of Building Information Modelling (BIM) Professional.* 5th Vocational Education International Conference. DOI: 10.2991/978-2-38476-198-2_213

Sarah, L. (2022) Building Information Modeling. Retrieved from https://constructible.trimble.com/construction-industry/what-is-bim-building-information-modeling. 2023, April 6

Sharif, T.H., & Ulil-Amor, B. Z. (2022). Introducing bim in outcome based curriculum in undergraduate programme of architecture : Based on students perception and lecture-lab combination. *Journal of Social Sciences and Humanities*, *6*(1), 1-11.doi:10.1016/j.ssaho.2022.100301

Usman, N., Nathaniel, J., & Danjuma, B. (2020). learning influence factors on building technology in colleges of education in Nigeria, *International Journal of Research and Innovation in Applied Science,5*(5), 24. https://www.rsisinternational.org/journals/ijrias/DigitalLibrary/Vol.5&Issue5/24-27.pdf

Wagbara, & Chinyere, D. (2025). University-industry partnerships for achieving decent employment in rivers state. *International Journal of Advance Research and Innovative Ideas in Education, 11*(2). 64-75. ijariie.com

EVALUATING THE PROFESSIONAL DEVELOPMENT NEEDS OF BUILDING TECHNOLOGY EDUCATORS IN THE APPLICATION OF ARTIFICIAL INTELLIGENCE FOR BUILDING DRAWING IN TECHNICAL COLLEGES OF FCT, ABUJA

[1]Mukaila Abiodun Yisa,[2]Sodehinde, Abidemi .O. [3]Raji, Farouk Abiodun, & [4]ABD - EL - AZIZ, A. ADEKUNLE.

[1&2]Department of Industrial Technical Education, College of Vocational and Technology Education, Tai Solarin University of Education, Ijagun, Ogun State, Nigeria.

[3&4]Department of Educational Technology, Technology Education Unit, Faculty of Education, University of Ilorin, Ilorin, Nigeria.

E-mail: raji.fa@unilorin.edu.ng **Mobile**: 08106604583

Abstract

This study was designed to assess the retraining needs of building technology teachers in the use of artificial intelligence in teaching building buildings in technical colleges in FCT, Abuja. Three research questions were answered and two null hypotheses were formulated and tested at 0.05 significance. A descriptive survey research design was adopted for the study and a well-structured questionnaire instrument developed by the researcher and validated by three Lecturers in the Department of Technology Education was used for data collection. The study was carried out in Technical colleges in FCT Abuja. The targeted population for the study was twenty-four (24) respondents consisting of administrative staff and building technology teachers of the technical colleges. The mean and standard deviation were used to answer the research questions while t-test statistic was used to test the hypothesis at 0.05 level of significance. The findings of the literacy level of BT teachers in using AI as instructional aids showed that they should improve. Findings on the possible challenges teachers faced in the use of AI for teaching building drawing in technical college in FCT, Abuja showed that they lack facilities needed to teach building drawing. Finding on the strategies to enhance in use of AI in teaching and learning building drawing in FCT, Abuja showed that they should provide adequate ICT tools and retrain technical teachers. The study there recommends that government should provide more AI instructional aids in every department in the technical colleges. The curriculum planners should integrate AI curriculum and enforce its use in instruction. The faculty board should organize seminars with training section to educate teachers and the student on AI and how to use it. There should be adequate power supply to power all electrical facilities. The AI used by the management of technical colleges should be adequately maintained. The federal, state and local government should allocate adequate fund to technical colleges in other teaching and learning more effective.

KEYWORDS: Building Technology Educators, Artificial Intelligence, Building Drawing

Introduction

Blocklaying, Bricklaying and Concreting (BBC) trade is one of the programme offered in technical colleges which lead to acquisition of practical and applied skills as well as basic scientific knowledge in building construction. Blocklaying, Bricklaying and Concreting (BBC) composed of five component subjects offered in the technical colleges which include introduction to building technology, building drawing, Blocklaying/ bricklaying, concreting and wall, floor & ceiling finishing. Building structure is composed of interrelated systems and assembled together to become a unit functioning (Clark, 2020). If these component are not carefully selected, specified, and detailed with drawing taking into account their effect on all the other parts of the building then the completed building may not be able to protect

its occupant from drafts, moisture intrusion, mould, condensation, cold, outside noise, or excessive heat.

Drawing building construction details demand high skills, but this detailing can less tedious and less time consuming when ICT is understood during the drawing work. It enables the production of better construction documents, and helps get better buildings built. Advanced technologies in housing construction are highly needed in technical colleges; this gives an insight on how to mark out detail when using Computer Aided Drafting (CAD) like AutoCAD. However, as with other innovations, it is expected that over time these newer technologies will gain wider acceptance and this will help to fasten building drawing (Boon, 2016).

Building drawing can be described as the design and drawing of building plans, elevations, sections, schedules and models. Swamy and Rao (2017) stated that Building is a structure that is built, while drawing is a graphical language that cannot be spoken or read aloud but easily understood by Engineers in any country. According to Randall (2018), drawing is a scaled representation of a building or parts of a building. Building Drawing has to do with skills acquisition and is capable of making one employable or being self-reliant.

From the ancient time pencil and paper has been the method used in building drawing and cardboard and strawboard has been in place for building modeling which a lot time and energy is been consumed by the teachers in teaching the student but to reduce this stress, technological advancement has led to the production AutoCAD, Revit, ArchiCAD and Sketch-up which deals with the use of computer for drawing building plan, sectioning, elevation and even 3D design. However, the teachers of building technology need to be train or retrain on this technological advancement to be updated so that such knowledge can be transfer to the student.

Building technology is not, and never will be transformative on its own, it requires teachers who can integrate technology into the curriculum and use it to improve student learning. In other words, computer cannot replace teachers; teacher is the key to whether technology is used appropriately and effectively. Experience around the world in developing industrialized countries has shown that teachers retraining in the use of computer as an application tool of technology is the key determine factor to improve student performance in terms of both knowledge acquisition and skill development enable by technology (James, 2017). The success of any initiatives to implement computer technology in educational program depends on the support and attitudes of teacher involved, and the need for proper retraining knowledge. It has been suggested that if technical colleges believed the important of computer, then there is need for retraining teachers who would need computer in their delicate field (James, 2017).

Retraining is defined as upgrading of existing skills or acquiring a new one. The teachers of Building Teachers program in the schools should be retrained periodically in to improve their performance and knowledge especially to make the students acquire the needed skills during teaching and learning session. The training and retraining of Building Teachers in the technical colleges is as vital as training of the industrial worker. The training should be a continuous process. Training is not something that is done to new employees only, but is used continuously in every well-ran organization. The training and retraining therefore, involves the acquisition of special skills and evidence of learning is manifested through the successful performance of these skills acquired. Building Teachers program in the technical colleges must therefore keep abreast with the new technological development and must keep on learning and acquiring new skills in order to be able to demonstrate knowledge and new skills to their students. Their training should not be confined to the class work or drawing studio alone, but engaged in conducting intensive research on local technologies.

The Technical Vocational Education (TVE) institutions especially technical colleges must provide its workers with the quickest possible methods at its disposal to be able to function effectively on the job. The training and retraining of teachers should provide them with skills and change of attitude to work, thereby improving their efficiency and productivity. Haruna (2021) defined training and retraining as those activities which are designed to improve performance on the job, the employee is presently doing or being hired to do. Training can also be visualized as the acquisition of knowledge, skills techniques, attitudes and experiences which enable an individual to make effective contribution to the combined effort of a team in the service delivery. The need for basic knowledge and skills needed for the roles the teachers would play in the teaching learning process is of vital concerned of the technical college, if the technical institution is to survive.

Training and retraining prepares the employee or individual worker such as Building Teachers to fit in, in the specific role they are expected to play. Training is the process of imparting specific skills which will equip the individual or group of people to perform specific jobs effectively, efficiently and diligently for effective and efficient training programs, training facilities must be provided for both the trainees. Training and retraining programs should expose the Building Teachers to the necessary facilities they have to work with in their fields. All institutions involved in the training of teachers should be adequately equipped. Technology education institutions have to be well equipped with gadgets, resources and materials essential for use in the classrooms and studio.

The ever changing role of the teachers, especially Building Drawing Teachers, demands professional teachers not only in name but also in training and status in the society. Goro (2020) stated that teachers must be provided with and have access to the necessary technological equipment training and resources that will result in enriched students learning. The teachers in training therefore, need quite a good number of infrastructure and educational facilities like machines, computers, tools, equipment and books. Teachers need to be provided with good recreational facilities for their physical mental and social developmental growth. The Federal Republic of Nigeria (FRN, 2024) acknowledges that no education system can be better than the teachers who operate it. So to get good quality technology education teachers, the personnel operating it must be well trained to be able to impart same to the students. Isa (2019) further stressed that a teacher who is occupationally qualified and competent in their subject areas can contribute immensely to the success of educational programs in their areas of specialization. Therefore, technology education needs qualified and good teachers or instructors to be able to achieve the programs desired objective.

Therefore, as we move into a technology based society, It is important that classroom experience with technology be equitable and unbiased for teacher; so that they can perform very well in building drawing. In most case, building teachers is to effective implementation of the use of transmit beliefs and values to student; it is important to understand the biases and stereotypes that building teachers may hold about the use of computers and the factors that act as facilitator to teacher "positive computer usage.

According to Kyle, (2021) retraining is the act of teaching a person a particular kind of skills and knowledge in a new way that relate to specific useful competencies. The pressures placed on our society as it changes from a manufacturing to an informational and technological economy as well documented. Building industries in Nigeria are hard pressed to stay ahead of the learning curve with regard to staying competitive this has led to the introduction of computer in building department in technical colleges, so that the student can gain skill in ICT, so that they can meet the current problem facing the economic. Computer is one of the main tools driving this change to an information age. It is within this climate that teachers are asked to get computer knowledge for proper teaching in the class room.

Nationally, the push to integrate computer into our classrooms comes from government, business, and industry. In Abuja, around 2019-2014, the state government announced an initiative to provide school teacher with computer, but on loan basis, so that they can have computer knowledge for the benefit of schools they are teaching.

Government, business, industry and educational leaders at the state level are placing new pressures on teacher to teach student to be knowledgeable computer user. Nigeria is requiring all students from secondary level to be skillful in computer knowledge. In support of the importance of teacher retraining need, technical college should retrain building teachers in auto CAD, and should be supported so that they can be able to impact good computer knowledge into the students. Olanrewaju, (2017) retraining of building teachers is quite useful in today's contemporary environment. The success of student learning with computer technology will depend on the training needs provided by the school to the teachers, and their willingness to include the computer technology (Obiegbu, 2022). Gaining an appreciation of the technical college in providing computer knowledge in the area of building technology is quite an improvement in building drawing No matter how sophisticated and powerful the state of building industry, computer technology is always needed for drawing of building structures (Duncan, 2022).

There are more cases of inadequate and ineffective retraining programmed than there are of success stories. Teacher remain the gate- keepers for student's access to educational opportunities afforded by technology; they should not be ignored (Matthews, 2008). Providing computer skills training to teacher in the use computer in drawing, teachers also need professional development in technical college, for skills improvement in teaching and learning of computer.

Statement of the problem

Early in 1987 Woodrow observed that the infusion of computer technology in to school curriculum has potential to drastically change education practices. However, to successfully change traditional practices, teachers must be positively train toward the educational issues involved. If teachers are resistance to change, the proposed curricular and procedural change will have a slim chance of success.

The use of new technologies such as computer has been a great challenge to teachers in technical colleges, building technology teachers do not seem to use these computers as aid for teaching building drawing. This implies that technical colleges' teachers are lagging behind in the use of computer for teaching building drawing in technical college which has led to experiencing much setback in the use of artificial intelligences such as AutoCAD, Revit, ArchiCAD, Sketch-up for teaching building drawings. Therefore, this study seek to determine the retraining needs of teacher for the use of artificial intelligences for teaching building drawings in technical colleges, Abuja.

Purpose of the study

The main purpose of this study is to determine the teachers retraining needs for the use of artificial intelligences in teaching building drawings in technical colleges, Abuja. Specifically this study determines:

1. The skills teachers needs retraining for the use of artificial intelligences in teaching building drawings.
2. The possible challenges teachers faced in the use of artificial intelligences in teaching building drawings.
3. The strategies that can improve teachers use of artificial intelligences in teaching building drawings.

Research Questions

1. What are the skills teachers needs retraining for the use of artificial intelligences for teaching building drawings?
2. What are the possible challenges teachers faced in the use of artificial intelligences for teaching building drawings?
3. What are the strategies that can improve teachers use of artificial intelligences for teaching building drawings?

Hypotheses

The following hypotheses were formulated and will be tested at 0.05 level of significant.
HO_1: There is no significance difference in the mean responses between the teachers and the administrators on the skills teachers needs retraining for the use of artificial intelligences in teaching building drawings.
HO_2: There is no significant difference in the mean response between the teachers and the administrators on the possible challenges teachers' faced in the use of artificial intelligences in teaching building drawings.

Methodology

In order to achieve the stated objectives of this research study, descriptive survey was adopted. The study will be carried out in all the Technical Colleges in Federal Capital Territory, Abuja. The entire population targeted for this study is 24 which comprises of 14 building technology teachers and 10 administrators (the principal, vice principal academic, vice principal admin, HOD and the Course Master) working at various technical colleges in Abuja. The entire population was used hence there will be no need of adopting any sample and sample techniques because the population is considered manageable enough to carry out the study. A structured questionnaire instrument developed by the researcher was used for this study. The instrument for data collection was given to (3) three expert in Technology Education Department, University of Ilorin. For both face and content validity. The instrument used for the data collection was administered to the respondent by the researcher and a research assistant within area of the study. All the 24 respondents was administered with the questionnaire. The mean, standard deviation and t-test was used to analyze data. The mean and standard deviation were used to answer the research questions while the t-test was used to test the null hypothesis at .05 level of significant.

Results

Research Question 1:

What are the skills retraining needs of building technology teachers in the use of Artificial intelligences for teaching building drawing?

Table 1: Mean respondents of Teachers and Administrator on the skills teachers needs retraining for the use of artificial intelligences for teaching building drawings
N_1 =12; N_2: =12; SA = Strongly agreed; A = Agreed; D = Disagreed; SD = Strongly Disagreed

S/N	ITEM	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_T$	Remark
1.	Word processing skills.	3.25	3.17	3.21	Agreed
2.	Corel draw application skills.	3.00	3.08	3.04	Agreed
3.	AutoCAD application skills.	3.67	3.17	3.42	Agreed
4.	ArchiCAD application skills.	3.83	3.75	3.79	Agreed
5.	Revit Architecture application skills.	3.75	3.67	3.71	Agreed
6.	Sketch-up application skills.	3.08	3.08	3.08	Agreed

7.	Chief-architect application skills.	3.17	3.50	3.34	Agreed
8.	Maintaining Artificial intelligence (AI) user interface skills.	3.67	3.50	3.59	Agreed
9.	Ability to project a Power Point Presentation.	3.75	3.33	3.54	Agreed
10.	Installation of computer application skills.	3.67	3.50	3.59	Agreed

Key: X_1 = Mean of Teachers; **X_2** = Mean of Administrator; **X_T** = Average of Mean of Teachers and Administrator, **N_1** = Number of Teachers; **N_2** = Number of Administrator.

The result presented in table 1 above revealed that the respondents (Teachers and Instructors) strongly agreed with all the items (i.e. all the respondents agreed) with mean score above **2.50,** this implies that all the listed items are skills teachers need retraining for the use of artificial intelligences for teaching building drawings.

Research Question 2:

What are the possible challenges teachers faced in the use of artificial intelligences for teaching building drawings?

Table 2: Mean respondents of Teachers and Administrator on the possible challenges teachers faced in the use of artificial intelligences for teaching building drawings

N_1 =12; N_2: =12; SA = Strongly agreed; A = Agreed; D = Disagreed; SD = Strongly Disagreed

S/N	ITEM	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_T$	Remark
1.	Poor financing of building technology teachers in the use of ICT by the government.	3.92	3.33	3.63	Agreed
2.	Lack of seminar provided by technical colleges in the use of ICT tools.	3.25	2.75	3.00	Agreed
3.	Poor provision of computers for training building drawing students.	3.75	3.25	3.50	Agreed
4.	Lack of motivation for teachers in the use of ICT.	3.50	2.25	2.88	Agreed
5.	Lack of electricity/alternating power supply.	3.75	3.25	3.50	Agreed
6.	Lack of AutoCAD application skills for training building technology teachers.	3.08	3.00	3.04	Agreed
7.	Unwillingness on the part of the building technology teachers in the use of ICT tools.	2.17	2.67	2.42	Disagreed
8.	Lack of ICT facilities for teaching building drawings in technical colleges.	3.17	3.00	3.09	Agreed
9.	No encouragement by government in providing computer system to technical colleges.	3.25	3.00	3.13	Agreed
10.	Lack of job satisfaction on the part of the building technology teachers.	1.92	2.75	2.34	Disagreed
11.	Teacher illiteracy in the application of ICT tools.	2.08	2.50	2.29	Disagreed
12.	Inadequate computer laboratory in technical colleges.	3.67	3.00	3.34	Agreed
13.	Obsolete curriculum	3.50	3.00	3.25	Agreed

Key: X_1 = Mean of Teachers; **X_2** = Mean of Administrator; **X_T** = Average of Mean of Teachers and Administrator, **N_1** = Number of Teachers; **N_2** = Number of Administrator.

The result presented in table 2 above revealed that the respondents (Teachers and Instructors) strongly agreed with all the items and with mean score above **2.50** excluding item 7**,** this implies that the entire listed challenges are faced by teachers in the use of artificial intelligences for teaching building drawings excluding unwillingness on the part of the building technology teachers in the use of ICT facilities.

Research Question 3:

What are the strategies that can improve teachers use of artificial intelligences for teaching building drawings?

Table 3: Mean respondents of Teachers and Administrator on the strategies that can improve teachers use of artificial intelligences for teaching building drawings N_1 =12; N_2 =12; SA = Strongly agreed; A = Agreed; D = Disagreed; SD = Strongly Disagreed

S/N	ITEM	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_T$	Remark
1.	Provision of computer centre unit in technical colleges.	3.83	3.50	3.67	Agreed
2.	Organizing seminars for building technology teacher in the application of ICT in Technical colleges.	3.33	3.83	3.58	Agreed
3.	Adequate provision of artificial intelligences for teachers in teaching building drawing.	3.83	3.42	3.63	Agreed
4.	Proper motivation for teachers during training of computer drawing in the use of artificial intelligences.	3.92	3.83	3.88	Agreed
5.	Adequate fixed facilities for computer training in building drawing.	3.50	3.17	3.34	Agreed
6.	Efficient and effective application of AutoCAD for building drawing.	3.50	3.08	3.29	Agreed
7.	Proper financing of building technology teachers training in the use of ICT tools by the government.	3.83	3.58	3.71	Agreed
8.	Adequate supply of electricity in technical colleges.	3.67	3.50	3.59	Agreed
9.	Skilled personnel should train and retrain building technology teachers on the use of artificial intelligences for teaching building technology.	3.17	3.08	3.13	Agreed
10.	ient training of staff in the use of ICT tools.	3.25	3.83	3.54	Agreed
11.	Provision of adequate computer laboratory in technical colleges.	3.67	3.75	3.71	Agreed

Key: X_1 = Mean of Teachers; X_2 = Mean of Administrator; X_T = Average of Mean of Teachers and Administrator, N_1 = Number of Teachers; N_2 = Number of Administrator.

The result presented in table 3 above revealed that the respondents (Teachers and Instructors) strongly agreed with all the items and with mean score above **2.50,** this implies that the entire listed item are strategies that can improve teachers use of artificial intelligences for teaching building drawings.

Hypothesis 1:

$H0_1$: There is no significant difference between the mean responses between the teachers and the administrators on the skills teachers needs retraining for the use of artificial intelligences in teaching building drawings.

Table 4: Standard Deviation and T-test analysis of the teachers and the administrators on the skills teachers needs retraining for the use of artificial intelligences in teaching building drawings

N_1 = 12; N_2: = 12; S = Significant; NS = Not Significant

S/N	ITEM	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_T$	SD_1	SD_2	T-Cal.	Remark
1.	Word processing skills.	3.25	3.17	3.21	0.45	0.39	1.09	NS
2.	Corel draw application skills.	3.00	3.08	3.04	0.43	0.29	-1.38	NS
3.	AutoCAD application skills.	3.67	3.17	3.42	0.49	0.39	6.68	S
4.	ArchiCAD application skills.	3.83	3.75	3.79	0.39	0.45	0.98	NS
5.	Revit Architecture application skills.	3.75	3.67	3.71	0.45	0.49	0.89	NS

6.	Sketch-up application skills.	3.08	3.08	3.08	0.67	0.67	0.00	NS
7.	Chief-architect application skills.	3.17	3.50	3.34	0.84	0.67	-2.56	NS
8.	Maintaining Artificial intelligence (AI) user interface skills.	3.67	3.50	3.59	0.49	0.52	1.79	NS
9.	Ability to project a Power Point Presentation.	3.75	3.33	3.54	0.45	0.49	4.70	S
10.	Installation of computer application skills.	3.67	3.50	3.59	0.49	0.52	1.79	NS

Key: N =Numbers of Teachers; **N_2**=Number of Administrators; **S** = Significant; **NS** = Not Significant SD_1=Standard Deviations of Teachers; SD_1= Standard Deviations of Administrators

Degree of Freedom (df) = $N_1 + N_2 - 2 = 22$, $T_{critical} = 1.96$

T-Cal. = T-test value of the Teachers and Administrators

The analysis in table 4 revealed that all the items that were *not significant* indicate that there is no significant difference in the mean response of Instructors and teachers, while item 3 and 9 shows that there is significant difference.

Therefore, we fail to reject the null hypothesis and conclude that skills teachers need retraining for the use of artificial intelligences in teaching building drawings.

Hypothesis 2:

$H0_1$: There is no significant difference between the mean response between the teachers and the administrators on the possible challenges teachers' faced in the use of artificial intelligences in teaching building drawings.

Table 5: Standard Deviation and T-test analysis of the teachers and the administrators on the possible challenges teachers' faced in the use of artificial intelligences in teaching building drawings

N_1 = 15; N_2: = 20; S = Significant; NS = Not Significant

S/N	ITEM	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_T$	SD_1	SD_2	T-Cal.	Remark
1.	Poor financing of building technology teachers in the use of ICT by the government.	3.92	3.33	3.63	0.29	0.49	6.88	S
2.	Lack of seminar provided by technical colleges in the use of ICT tools.	3.25	2.75	3.00	0.45	0.62	4.54	S
3.	Poor provision of computers for training building drawing students.	3.75	3.25	3.50	0.45	0.75	3.80	S
4.	Lack of motivation for teachers in the use of ICT.	3.50	2.25	2.88	0.67	0.45	13.78	S
5.	Lack of electricity/alternating power supply.	3.75	3.25	3.50	0.45	0.45	6.01	S
6.	Lack of AutoCAD application skills for training building technology teachers.	3.08	3.00	3.04	0.52	0.00	2.14	S
7.	Unwillingness on the part of the building technology teachers in the use of ICT tools.	2.17	2.67	2.42	0.72	0.89	-3.15	NS
8.	Lack of ICT facilities for teaching building drawings in technical colleges.	3.17	3.00	3.09	0.39	0.60	1.61	NS
9.	No encouragement by government in providing computer system to technical colleges.	3.25	3.00	3.13	0.75	0.43	2.76	S
10.	Lack of job satisfaction on the part of the building technology teachers.	1.92	2.75	2.34	0.52	0.87	-5.49	NS
11.	Teacher illiteracy in the application of ICT tools.	2.08	2.50	2.29	0.52	0.67	-3.50	NS
12.	Inadequate computer laboratory in technical			3.34			6.20	

colleges.	3.67	3.00		0.49	0.60		S
13. Obsolete curriculum	3.50	3.00	3.25	0.67	0.60	4.42	S

Key: N =Numbers of Teachers; **N_2**=Number of Administrators; **S** = Significant; **NS** = Not Significant SD_1=Standard Deviations of Teachers; SD_1= Standard Deviations of Administrators

Degree of Freedom (df) = $N_1 + N_2 - 2 = 35$, $T_{critical} = 1.96$

T-Cal. = T-test value of the Teachers and Administrators

The analysis in table 5 revealed that all the items that were *significant* indicate that there is significant difference in the mean response of Instructors and teachers, while item 7, 8, 10 and 11 shows that there is no significant difference. Majority of the listed possible challenges are faced by teachers in the use of artificial intelligences in teaching building drawings.

Discussion of Findings

The discussion of findings based on the research question and statement of hypothesis of the study.

The findings on the retraining of skills teachers for the use of artificial intelligences for teaching building drawings revealed that the respondents (Teachers and Instructors) strongly agreed with all the items (i.e. all the respondents agreed) with mean score above **2.50,** this implies that all the listed items are skills teachers need retraining for the use of artificial intelligences for teaching building drawings. The finding shows that the following skills are needed by teachers in the use of artificial intelligences for teaching building drawings: Word processing skills, Corel draw application skills, Auto CAD application skills, ArchiCAD application skills, Revit Architecture application skills, Sketch-up application skills, Chief-architect application skills, Maintaining Artificial intelligence (AI) user interface skills, Ability to project a Power Point Presentation, Installation of computer application skills. The testing of hypothesis deduced that we fail to reject the null hypothesis and conclude that skills teachers need retraining for the use of artificial intelligences in teaching building drawings. This is in line with (Harris, 2020) who emphasized that diverse Software availability and teacher willingness to use the software can have positive effects on the teacher attitudes towards the adoption of technology in the classroom, thereby enhancing the student academic performance.

The findings on the possible challenges teachers faced in the use of artificial intelligences for teaching building drawings revealed that the respondents (Teachers and Administrator) strongly agreed with all the items and with mean score above **2.50** excluding item 7**,** this implies that the entire listed challenges are faced by teachers in the use of artificial intelligences for teaching building drawings excluding unwillingness on the part of the building technology teachers in the use of ICT facilities. The finding shows that the following are possible challenges teachers faced in the use of artificial intelligences for teaching building drawings: Poor financing of building technology teachers in the use of ICT by the government, Lack of seminar provided by technical colleges in the use of ICT tools, Poor provision of computers for training building drawing students, Lack of motivation for teachers in the use of ICT, Lack of electricity/alternating power supply, Lack of AutoCAD application skills for training building technology teachers, Lack of ICT facilities for teaching building drawings in technical colleges, No encouragement by government in providing computer system to technical colleges, Lack of job satisfaction on the part of the building technology teachers, Teacher illiteracy in the application of ICT tools, Inadequate computer laboratory in technical colleges, Obsolete curriculum while unwillingness on the part of the building technology teachers in the use of ICT tools is not part of the possible challenges teachers faced in the use of artificial intelligences for teaching building drawings.

The testing of hypothesis shows that majority of the listed possible challenges are faced by teachers in the use of artificial intelligences in teaching building drawings. This is in line with Ukeje (2022) who indicate that qualitative and quantitative deficiencies in building teachers are one of the factors that pose challenges against the use of computer in building drawing effectively. UNESCO (2022) also found that lack of funds could hinder someone from undergoing training especially where it involves payment of fees and so on. This is where it becomes crucial for every organization to have a scheme that will carter for those that cannot afford to attend any seminars or training programme provided.

The findings on the strategies that can improve teachers use of artificial intelligences for teaching building drawings revealed that the respondents (Teachers and Instructors) strongly agreed with all the items and with mean score above **2.50,** this implies that the entire listed item are strategies that can improve teachers use of artificial intelligences for teaching building drawings. The finding shows that the following are the strategies that can improve teachers use of artificial intelligences for teaching building drawings: Provision of computer centre unit in technical colleges, Organizing seminars for building technology teacher in the application of ICT in Technical colleges, Adequate provision of artificial intelligences for teachers in teaching building drawing, Proper motivation for teachers during training of computer drawing in the use of artificial intelligences, Adequate fixed facilities for computer training in building drawing, Efficient and effective application of AutoCAD for building drawing, Proper financing of building technology teachers training in the use of ICT tools by the government, Adequate supply of electricity in technical colleges, Skilled personnel should train and retrain building technology teachers on the use of artificial intelligences for teaching building technology, Sufficient training of staff in the use of ICT tools, Provision of adequate computer laboratory in technical colleges.

This is in line to (UNESCO 2024) that Information and communication technologies (ICTs) can improve pre-service teacher training, by providing access to more and better educational resources, offering multimedia simulations of good teaching practice, catalyzing teacher-to trainee collaboration and increasing productivity of non-instructional tasks.

Conclusion

The analysis of the findings revealed that all is deeded to be done in teaching building technology, and for building drawing to be adequate and effective, there is need for technical colleges to train the teacher before procuring those artificial intelligences for teaching building drawing. It is also suggested that government should support technical colleges by providing adequate supply of electricity in technical colleges to facilitate effective teaching and learning.

Recommendations

The following recommendations were made for implementation;

1. Strategies should be put in place by government in organizing seminars for building technology teacher in the application of ICT in technical colleges.
2. The government should provide Proper financing of building technology teachers training in the use of ICT tools
3. The government should provide adequate supply of electricity in technical colleges in other power the computers and other electrical facilities to aid effective teaching and learning.

References

Anumbea, C. J. (2016). Potential for improving site management practices through knowledge management, Construction Innovation, Information, process, Management, Volume 6, issue 4, Pp232- 249.

Best, D. (2022). School Effectiveness and Quality Improvement: Quality Teaching in Nigerian Secondary School. The African Symposium, Vol. 5(4), pp. 17-31.

Beuer, M. Kenton, O. P (2025). Construction and application of viral School. Internet learning environment in middle and elementary school.

Clark, B. (2020). Computer- based instruction: Methods and development . New jersey: prentice – Hall.

Duncan, C. (2022). New Aspect of Quantity Surveying Practice: A text for all Construction Professionals, Elsevier Butterworth – Heinemann, UK.

Henry, N. O (2025). Information and communication technology: Complete program of studies, Kindergarten to grade 12. Retrieved February 15, 2017, from http://www.learning.gov.ab.ca/ict/pofs.pdfHarris, N.O (1995) coming to teaching in the 21st century: A research study conducted by the Galileo Educational Network. Report for Alberta Learning. February 15, 2017, from http://www.galileo.org/research/publications/ctt.pdf.

James, D. (2022). E-learning for the workplace: *Creating canada's Lifelong Learners. Retrieved, February 2, 2001 from the world wide web: http://www.conferenceboard.ca/education/e-learning_for_the_workplace.pdf.*

James, K. (2017). Experienced teacher learning within the context of reAIrocal peer coaching. *Teachers and teaching: Theory and practice, 13(2), 165-187.*

Johansson, O. (2020) Integrating ICT in STM Classrooms: status and Implications. STAN proceedings of the 44th annual Conference, 58-60.

Jude, k. L. (2020). Technology is the Answer! But what was the Question? Capstone College of Education Society, University of Alabama (Eric Document Reproduction Service No: 381152).

Kolalwole, M. A. (2022). The fuctions of builders in building Construction Companies. Being a paper presented at the 32nd Annual General meeting/Conference with the theme Building Production Management Service in construction organised by the Nigerian Institute of Building at Maiduguri international Hotel, Maiduguri-Borno State, 3rd-6th July.

Nwosu, C. (2023). Integrating ICT in STM Classroom: Status and Implications. STAN Proceedings of the 44th Annual Conference, 58-60.

Olanrewaju, A. A. (2017). Determining whether Value Management is practiced in the Nigerian construction industry, in: *proceeding of Quality Surveying international Convention (QSIC).* Jointly organized by Visit Malaysia 2-7; International Islamic University Malaysia; Board of Quantity Surveyors Malaysia; Institution of Surveyors Malaysia; JKR and CIDB. Held on 4-5th September 2017, kuala Lumpur.

Ololube, N. P. (2025). Benchmarking the Motivational Competencies of Academically Qualified Teachers and Professionally Qualified Teachers in Nigerian Secondary Scchools. The African symposium, Vol. 5(3), PP. 17-35.

Onwegbuzie, Q .G. (2017). A mixed methods investigation of mixed method sampling designs in social and health science research. *Journal of mixed research. 1(3), pp 267-294.*

Richeardson C. P. (2019). " Aframwork to Articulate the impact of ICT on learning in Schools" perth; Special Education Service.

Taiwo, A. A&Afolabi, J.A. (2021). Incessant building collapse: A case of a hotel in akure, Nigeria. *Journal of building appraisal volume 6, issue 3/4, pp 341-348.*

Taylor, (2020). Information and Communication Technology. Computer as a tutor, computer as stimulating tools.

Taylor, N. F. (2020). Teachers Instructional Material Utilization Competencies in Secondary Schools in Sub-Saharan Africa: professional and nonprofessional teachers perspective" in Conference proceedings of the 6th International Educational Technology Conference EMU, 19-21 April 2016 North Cyprus.

Ukeje, B. O. (2022). The future of teacher education in Nigeria. In *Teachers Education in Nigeria: past, present and future- proceeding of the first Teachers' Summit*. Kaduna. NTI.

Underwood, K. (2024). Communicative Computer Assisted. *Communicative teaching approaches promoted communicative competence and real communication. 1970s and early 1980s.*

United Nation Educational Society and Cultural Organization. (2022*). Information and Communication Technology in Education- A Curriculum for schools and programme for Teachers Development. Paris:* UNESCO.

United Nation Educational Society and Cultural Organization. (2024) Techer Education Retrieved 19th March 2025, form http://portal.unesco.org/education/en/ev.php

Weston. (2023). Innovation in Technical Skills Acquisition for Teacher.

INFLUENCE OF 3D BUILDING MODELING AS AN INSTRUCTIONAL TOOL ON STUDENTS' ACADEMIC PERFORMANCE IN BUILDING TECHNOLOGY IN TECHNICAL COLLEGES OF NIGER STATE

[1]Raji, Farouk Abiodun, [2]Lemo, Olusiji Olaseni, [3]Fadairo, Oriola Olatunji, [4]Bolatito, Mathew Olatunde, & [5]Shosanya, Abuldrasheed Oluwatobi

1Department of Educational Technology, Technology Education Unit, University of Ilorin, Ilorin Nigeria.

2,3,4&5Department of Industrial Technical Education, Tai Solarin University of Education, Ijagun, Ogun State.

Email:- raji.fa@unilorin .edu.ng Phone:- 08106604583

Abstract

This study was designed to determine the influence of 3D building modeling as an instructional Tool on students' academic performance in building technology in Technical Colleges of Niger State. Two technical colleges were selected for the study using simple random sampling technique. One of the schools was used as the experimental group and the other one as the control group. 20 students were randomly selected for each consisting of male and female of equal proportion. The experimental group ware taught using 3D building model and the control group were taught using the conventional building model. The research instrument used for the study was building technology Achievement Test covering the topic selected for the study. The data were collected and analyzed using t-test statistics respectively. Two hypotheses were postulated and tested at 0.05 level of significance. After the analysis and final result was gotten, it showed that students who were taught using 3D building model performed better than those that were taught using the conventional lecture method. In the light of that, it was recommended that 3D building should be used for the teaching and learning of building technology in technical colleges.

KEYWORDS: 3D Building modelling, instructional tool, academic performance, building technology, technical colleges

Introduction

Buildings are constructed to serve the needs of their occupants. Occupants need Facilities with comfortable, safe and healthy environments, utilities and technical equipments to perform their work. Building systems may be defined as a group of electro-mechanical components connected by suitable pathways for the transmission of energy, materials or information and directed to a specific Purpose. An integrated approach to building systems gives consideration to the Overall objectives rather than the individual elements, components and Subsystems. Traditionally, coordination of building systems is primarily between mechanical and electrical engineers that is passed down the line to contractors to coordinate on site. In the past two decades the integration of diverse technologies such as mechanical, electrical, bioclimatology, geophysics, optics, electronics and computer engineering plays an important role in the design of building systems and the environment they control. Building systems applications may include heating, ventilation, air conditioning, and cooling (HVAC); lighting; power; security; fire and life safety; building automation; audiovisual communications and computer networking of various kinds. Because of the large number of interrelated factors in these systems, there can be many solutions to the same building problem, all of which will satisfy the minimum requirements (Ahuja,1997).

The computerization and integration of building systems technology and the information age we live in have changed the way humans perceive their habitat. Computers are mathematical

instruments of enormous value in the science of building systems design. Computer-aided design (CAD) systems are extremely valuable tools in drafting and modelling. This chapter introduces 3D CAD modelling as a tool to support the coordination of building systems in designing, construction and maintenance. Nowadays 3d modeling is being used even more widely from medicine to engineering applications. The involvement of Geomatics engineering with use of spatial data and the improving use of geographic information systems, both in our country and around the world, and the need to be relieved from the restrictions analog maps revived the subject of intense use of digital maps and spatial modeling. 3D modeling and visualization has made a rapid development parallel to the technology, especially altogether with animations, the use of these models are more frequent than it was before. Early computer graphics were Vector graphics, composed of thin lines whereas modern day graphics are Raster based using pixels. The first triangulated irregular network program for GIS was written by Randolph Franklin at Simon Fraser University in 1973. A major breakthrough in simulating realism began in 1975 when the French mathematician, Dr. Benoit Mandelbrot published a paper called "A Theory of Fractal Sets." After some 20 years of research he published his findings and named them Fractal Geometry. At the 1980 SIGGRAPH conference a film entitled "Vol Libre" was shown. It was a computer generated high-speed flight through rugged fractal mountains. A programmer by the name of Loren Carpenter from The Boeing Company in Seattle, Washington had studied the research of Mandelbrot and then modified it to simulate realistic fractal mountains.

Two-dimensional forms, recognize, depth and distance proximity. Identify and understand relationships of location, position, scale and size. Spatial orientation refers to the ability to recognize the identity of a object when it is seen from different angles.(Tremblay, 2024).

Spatial ability is fundamental to human functioning in the physical world, spatial reasoning enables an individual to use concepts of shapes features and relationship in both concrete and abstract ways, to make and use things in the world to navigate, visualize and to communicate (Newcomer,Raudebaugh,Mckelland Kelly.1999).In a similar way this ability is used to envision new things and establish relationship of concepts in the mind (jones and bills 1998).

Basham(2017) noted that spatial ability is basic to higher level activities such as mathematical thinking and used for processing information presented in such representation s maps, graph, diagrams and other spatial layout. According to Olkun (2023)spatial thinking is used to represent and manipulate information in learning and problem solving in engineering designs, physics and mathematics.

AutoCAD is on of the computer aided design (CAD) software package currently available for graphic design. It is an interactive drafting software package for construction of object on a graphics display screen, according to Bui(2024)AutoCAD is a vector graphic software developed in early 1980s by Autodesk incorporation for Two-dimensional and Three-dimensional design and drafting. It uses primitive entities such as lines, poylines, circle, arcs and as foundation for more complex object(Wikipedia,2017)AutoCAD provides users with solid modeling option, vpoint, solview and soldraw commands.

Statement of the problem

Technical college graduates are suppose to have three options according to the National policy on Education(FGN 2024) is either to secure employment in the industries, pursue further education in higher technical institution or set us a business and become self employed. One of the causes of high failure rate of student in recent years according to NABTEB(2002) chief examiner reports is partly due to teaching methods In view of the above observation, this researcher is designed to examine the effect of 3d building model on

student academic performance in building technology in some selected government technical college in Niger state.

Purpose of the study

The main purpose of this research is to find out the following

1. To find out the effect of 3D building model on student academic performance in building technology in some selected government technical college in Niger state.
2. To find out the differences among male and females students taught with 3D building model

Research Question

1. What is the effect of using 3D building model in teaching building technology
2. Is there any difference among male and female students taught using 3D building model.

Research Hypotheses

The research hypotheses therefore are:

1. There is no difference in the mean achievement score of the students taught using 3D building model and those taught using the conventional method of building model.
2. There is no difference in the academic performance of male and female students taught using 3D building model.

Methodology

The quasi experimental research design was used for the study involving the pre-test, post-test, experimental and control group. The study was conducted in some selected government technical colleges in Niger state Nigeria. The total population of students from both school is 60, government technical college minna has 32 students offering building technology and government technical college new bussa has 28 students offering building technology. The sample size for the experiment is 20 students which was drawn from government technical college minna and anothere 20 students drawn from government technical college new bussa. They were both used respectively as control group and experimental group to test the hypotheses(HO1). Another 20 atudents compromising of ten(10) and ten(10)female students were drawn to test the hypotheses on gender disparity. The instrument used for collecting data was fifteen(15)objective question,the scope of th test was limited to the concept treated in building technology. After testing for validity,the instrument was administered to 40 building technology student and then results were collated, after a period of wo weeks the test items were readministered to the same students,the first and second result were corelated using pearson product moment correlation (PPMC). The experiment commenced with the administration of pretest to all the treatment groups,building technology teachers and their assistants administred the pretest to the treatment group in their respective schools. The scripts of the post-test were scored, collated, coded and analyzed using statistical analysis to find solutions to the questioned raised using mean, standard deviation and t-test. They were computed to test the mean scores of the two groups of students used in the study. The significant level for testing hypotheses is at 0.05. this level of significance formed the basis for retaining or rejecting each stated hypotheses.

Results

The summary of the data analysis and result is presented below:

Table 1 pretest mean score of experimental and control group

Variables	N	d.f	Mean	Sd	t-value calculated	t-value critical	p≤
Experimental group	20	19	8.90	2.90	1.140	1.684	0.05
Control group	20	19	7.85	2.77	1.140	1.684	0.05

Source: Field survey,(2012)

The result in table 1 above shows no significant difference between the pretest mean score of the experimental group (8.90) and the control group (7.85).This shows that both groups were at same entry level of academic ability before the use of 3D CAD building model for instruction.

Hypotheses 1(H01)

There is no significant difference in the mean achievement score of students taught using 3D CAD building model and the conventional building model

Table 2 post-test mean score of the experimental and control group.

Variables	N	d.f	Mean	Sd	t-value calculated	t-value critical	p≤
Experimental group	20	19	10.3	3.33	3.14	1.684	0.05
Control group	20	19	7.35	2.38	3.14	1.684	0.05

Source: Field survey,(2012)

Table 2 shows that the post-test mean score of experimental group is (10.3) and the control group is (7.35).The calculated t-value(3.14) is greater than the critical t-value(1.684).Thus, this implies that, there is a significant difference in mean achievement score of students taught using the 3D CAD building model and students taught traditional building model. Therefore, the null hypothesis (HO1) is rejected.

Hypotheses 2(HO2)

There is no significant difference in the mean achievement score of male and female students taught with the 3D CAD building model.

table 3 post-test mean score of male and female experimental and control group.

Variables	N	d.f	Mean	Sd	t-value calculated	t-value critical	p≤
Male group	10	9	9.1	3.21	1.127	1.725	0.05
Female group	10	9	7.5	2.81	1.127	1.725	0.05

Source: Field survey,(2012)

Table 3 result shows that the calculated t-value(1.127) is less than the critical t-value(1.725).This indicates that there is no significant difference in the post-test mean score of male(3.21) and female (2.81) students taught using 3D CAD building model. Thus, the null hypotheses 2(HO2) is accepted.

Discussion of results

The results of table 1 indicated that the two groups were at same entry level with regards to their academic ability before the teaching was presented to them. Hence, there is no significant difference in their test mean score.

The result in table 2 indicated that there was significant difference in the achievement of students taught using 3D building model and those taught with the conventional building model. This implies that the experimental group performed better than the control. This means that use of 3D building model had a positive influence on student performance. Thus, the word of Adeoti(1998), can be quoted who defined instructional material as things which are intended to help the teacher to teach more effectively and also enable the pupil to learn more effectively

The result in table 3 indicated that there was no significant difference in the performance of male and female students taught using 3D building model. The result shows equality on their performance towards the concept. That is, both the male and female students have similar performance. Thus, this result supports, Alfa(2017).who stated that there is no significant difference in the performance of male and female students in WAEC and NECO result score. Also Nwogy (2016) and Gambari (2023)found the performance of male and female student equal in their study

Conclusion

1. Teaching with multimedia (3D CAD)saves time makes effective teaching and improve performance of students in building technology
2. The student's enthusiasm and participation during the teaching, using the 3D building showed that they were happy and seemed to understand more than the conventional building model.
3. There was increased in the performance of students in building technology when 3D building model is used to teach compared to those taught conventional building model.

Recommendations

The following recommendations were made

1. Building technology teachers should be encouraged as much as possible to use multimedia instruction. This will enhance the better understanding of concepts in sciences.
2. The government and schools should aimed at providing computers and other peripherals needed for effective and efficient utilization of 3D CAD building model in teaching and learning
3. Further curriculum development should take full account of the potential of a new technology.

References

Arslan A. E., Ergun F., 3D modeling of I.T.U. Civil Engineering Faculty Building into Google Earth, I.T.sU. Design Project Report 2018, Istanbul.

Batty, M. , Urban Modeling, International Encyclopedia of Human Geography 2017 Deng, F., Zhang, Z., Zhang, J., Construct 3D City Model by Multi-Sensor Data, ISPRS Workshop on Service and Application of Spatial Data Infrastructure, XXXVI (4/W6), Oct.14-16, Hangzhou, China

Hu, J. You S. , Neumann U. ,Approaches to Large-Scale Urban Modeling, IEEE Computer Graphics and Applications Magazine, November/December 2023

Jarvis, D. , 3D Graphics Modeling and Rendering mini−howto v1.1, 27 March 2021

Kolbe, T. , Bacharach, S. , An Open Standard for 3D City Models ,Directions Magazine, July 03, 2016

Lancelle, M., Fellner, D. W., Current issues on 3D city models, Computer Graphics, University of Technology at Braunschweig 2023/2024

Lin, C. Y.: 2021, A digital procedure of building construction, in Gero, J., Chase, S. and Rosenman, M. (eds), CAADRIA2021, Key Centre of Design Computing and Cognition, University of Sydney, pp. 459-468

Pollefeys, M. , Visual 3D Modeling from Images, Tutorial Notes 2017

Szalapaj, P.: 2021, CAD Principles for Architectural Design, Architectural Press, Oxford.

Se, S. , Jasiobedzki, P., Photo-realistic 3D Model Reconstruction, Proceedings of the 2016 IEEE International Conference on Robotics and Automation Orlando, Florida – May 2016

Tao, G. ,3D City Modeling Using High resolution Satellite Image and Airborne Laser Scanning Data, Yasuoka Lab. IIS, The University of Tokyo July 2023

ENHANCING TEACHING AND LEARNING OF TECHNICAL DRAWING THROUGH ARTIFICIAL INTELLIGENCE TOOLS IN TECHNICAL COLLEGES IN NIGER STATE

[1]Binni Danjuma Beji PhD., [2]r. Akinduro Ifeoluwa Reuben & [3]Dr. Umar Muhammad Ahmad
[1]Department of Building Technology
Niger State College of Education, Minna, Niger State
+2348060895999
[2]Department of Industrial Technology and Vocational Education,
Adekunle Ajasin University, Akungba, Akoko, Ondo State
+2348062803723
Ifeoluwa.akinduro@aaua.edu.ng
[3]College of Engineering
Umaru Ali Shinkafi Polytechnic, Sokoto
umarmuhdahmad@yahoo.com

Abstract

This study investigated the impact of artificial intelligence tools on the academic performance and interest of students in technical drawing within technical colleges. A total of 117 students specializing in technical drawing formed the study sample. These were intact classes, with 68 students assigned to the experimental group and 49 to the control group. Two technical colleges were selected from the seven available in Niger State using a random sampling approach through the balloting method. The study adopted a pre-test, post-test quasi-experimental design. The instruments used for data collection were the Technical Drawing Achievement Test (TDAT) and the Technical Drawing Interest Rating Scale (TDIRS), both of which were validated and found reliable, with coefficients of 0.75 and 0.78, respectively. The hypotheses formulated were tested using the t-test statistical tool at a 0.05 level of significance. The major findings revealed a significant difference in achievement and interest among students taught using artificial intelligence tools compared to those taught through conventional methods. However, no significant difference was observed in the achievement and interest levels between male and female students exposed to the AI-based instructional tools. Based on these findings, it was recommended, among other things, that the National Board for Technical Education (NBTE) and relevant government agencies should ensure the provision of computers and AI-driven educational software, as well as ongoing training for technical drawing teachers in modern instructional strategies.

Keywords: Artificial intelligence, , technical drawing, technical colleges, students, achievement, interest, Technical drawing

Introduction

A technical college is a structured institution dedicated to providing specialized education aimed at equipping students with the practical skills and theoretical knowledge required for meaningful employment in various occupational fields. As Abdulkadir (2021) affirms, technical college education in Nigeria is responsible for offering full-time programmes in areas such as technology, applied sciences, and commerce—disciplines that are vital to the nation's socio-economic advancement. According to the Federal Republic of Nigeria (2023), the principal aim of technical colleges is to train craftsmen who possess employable skills, sound knowledge, and the right attitude to thrive in different vocational disciplines,

including Technical Drawing. Technical Drawing is one of the foundational subjects taught in technical colleges across Nigeria. It serves as a critical trade subject that supports multiple vocational areas by fostering the ability to communicate engineering and architectural ideas through precise graphical representation. Students who undergo training in Technical Drawing work towards earning the National Technical Certificate (NTC) and, at advanced levels, the Advanced National Technical Certificate (ANTC), which recognize them as craftsmen and master craftsmen, respectively. The National Board for Technical Education (NBTE, 2021) notes that the core objective of Technical Drawing is to produce highly skilled individuals who are proficient in visualizing, interpreting, and preparing technical diagrams using conventional drafting tools and modern digital platforms, all of which are essential in construction, manufacturing, and engineering industries. The attainment of this goal is largely contingent upon the competence of the instructors. A teacher, in this context, is viewed as a seasoned professional with deep mastery of both the content and the pedagogical techniques necessary to inspire, instruct, and guide students toward vocational excellence.

Artificial intelligence presents an entirely new learning environment for students, thus requiring a different skill set to be successful (Tseng *et al.*, 2020) Critical thinking, research, and evaluation skills are growing in importance as students have increasing volumes of information from a variety of sources to sort through (Ali, 2021). Also, particularly in courses that are entirely electronic, students are much more independent than in the traditional setting. This requires that they are highly motivated and committed to learning (Tekinarslan, *et al.*, 2023). They have less social interaction with peers or an instructor. Students in online courses tend to do as well as those in conventional classrooms, but there is higher incidence of withdrawal or incomplete grades (Bell *et al.*, 2020). Artificial intelligence can be viewed as computer assisted learning, and as pedagogy for student-centered and collaborative learning. Early developments in Artificial intelligence focused on computer assisted learning, where part or all of the learning content is delivered digitally. More recently the pedagogical dimension of Artificial intelligence has become prominent. Artificial intelligence comprises all forms of electronically supported learning and teaching. The information and communication systems, whether networked learning or not, serve as specific media to implement the learning process. Artificial intelligence plays very crucial role in teaching content effectively. If there are qualified teachers, recommended textbooks, but no adequate Artificial intelligence facilities, this may affect learning and teaching of Technical drawing in technical colleges for better academic achievement.

The problem of poor achievement of students could be attributed to poor instructional methods used by teachers in teaching Technical drawing. Academic achievement, according to Dori (2025), refers to some method of expressing a student scholastic standing. As a result, the students at the technical colleges find it difficult to cope with the required standard presented to them. These poor instructional methods could lead to lack of interest on the part of the learners.

Interest is an important variable in learning because when one becomes interested in an activity, one is likely to be more deeply involved in that activity. Interest is a subjective feeling of concentration or curiosity over something. It is the preference for particular types of activities, that is, tendency to seek out and participate in certain activities (Agwagah, 2024). It is on this note that this study is considered necessary.

Statement of the Problem

Observation over the years is that students' achievement in Technical drawing at technical colleges, has not been very encouraging. According to NABTEB (2018), candidates that offered Technical drawing performed poorly in the areas of acquire the skills of applying scientific knowledge in solving technology problems. Many factors can contribute to this

unacceptable trend the poor performance of Technical drawing students. One of such factors could be lack/inadequate Artificial intelligence facilities in our schools.

This study therefore intends to make a trust into the problem and thus pose the following questions:

a) What is the effect of Artificial intelligence on students‟ achievement and interest in the study of Technical drawing?
b) To what extent does the effect of Artificial intelligence affect students‟ achievements and interest in Technical drawing?

Purpose of the Study

1) There is significance difference in mean achievement of students taught using Artificial intelligences and those taught using conventional teaching method.
2) There is significance difference in mean interest rating between students taught using Artificial intelligence and those taught using the conventional teaching method.
3) There is significance difference in mean achievement score between boys and girls taught using computer assisted instructions.
4) There is significance difference in mean interest rating score between boys and girls taught using computer assisted instructions.

Research Questions

(1) What is the mean achievement scores of students taught Technical drawing with Artificial intelligences and those taught using the conventional teaching method?
(2) What are the mean interest ratings of students taught Technical drawing with Artificial intelligences and those taught using the conventional teaching method?
(3) Is there any significance difference in the achievement?
(4) To what extent does the interest of rating of boys and girls differ from girls taught Technical drawing using Artificial intelligences?

Hypothesis

The following null hypotheses were tested at 0.05 level of significance.

HO_1: There is no significant difference between the mean achievement scores of students taught Technical drawing with Artificial intelligences and those taught using conventional teaching method.

HO_2: There is no significant difference between the mean interest rating of students taught Technical drawing with Artificial intelligences and those taught using conventional teaching method.

$H0_3$: There is no significant difference between the mean achievement scores of boys and girls taught Technical drawing using Artificial intelligences.

HO_4: There is no significant difference in the mean interest rating between of boys and girls taught Technical drawing using Artificial intelligences.

METHODOLOGY

The design used in this study is the pre-test, post-test quasi experimental-control research design. The research was carried out in Technical Colleges in Niger State. The population for the study comprised of all Technical drawing students in all technical colleges in Niger State. The sample used for this study consists of one hundred and seventeen students in which chosen from two intact classes randomly drawn in the area of study considering time, cost and administrative constraints and experimental nature of the study. The two technical colleges used are Government Technical College, Minna and Suleiman Barau Technical College, Suleja.

The instruments used for data collection are; Technical drawing Achievement test (TDAT) and Interest in Technical drawing Rating Scale (ITDRS). The instruments were validated by two experts from school of technical education, Niger State College of Education, Minna. The reliability of the instrument, Interest in Technical drawing Rating Scale for this study was calculated using Cronbach's alpha reliability and found to 0.75. The split half method of reliability was used on the other instrument (achievement test), the results were correlated using Product Moment correlation and the calculated reliability coefficient was 0.78.

In each of the two technical colleges used for the study, the researcher used one intact class for each school. This is to avoid the experimental group students from mixing up with the control group students to exchange ideas. This was controlled by not allowing them know that they were used for the study which could be achieved by teaching all the classes by their original teachers.

Interest in Technical drawing rating scale (ITDRS) and the achievement test were jointly administered directly to the two intact classes of TC II students of the selected technical colleges after getting permission from the principal. The instruments were administered before and after the exposure of treatment to the experimental group. Mean and standard deviation was used to answer the research questions. The hypotheses stated were tested using t-tests at 0.05 level of significance and used for the acceptance or rejection of the state hypothesis.

RESULTS

Research Questions One

What are the mean achievement scores of students taught Technical drawing with Artificial intelligences and those taught using the conventional teaching method?

Table I: Mean of pre-test and post test scores of experimental and control groups in the achievement test.

Group	N	Pre test	Post test	Mean Gain
Experimental	68	20.12	50.51	30.39
Control	49	16.28	45.16	28.88

The data presented in table 1 shows that the experimental group taught Technical drawing with Artificial intelligences had a mean achievement score gain of 30.39 ahead of the control group with a mean gain of 28.88.With this result, the students in the experimental group performed better in the achievement test than the students in the control group.

Research Question Two

What is the mean interest in Technical drawing rating of students" taught Technical drawing with Artificial intelligences and those taught using the conventional teaching methods?

Table 2: Mean of pre-test and post-test scores of experimental and control groups in the interest inventory items.

Group	N	Pre-test	Post-test	Mean Gain
Experimental	68	25	56	31
Control	49	17	43	26

Table 2 shows that the experimental group taught Technical drawing with Artificial intelligences had a mean interest rating gain score of 31 while the control groups had 26 mean rating score. This result indicates that interest in Technical drawing of students in the experimental group is higher than the interest of the students in the control group.

Research Question Three

Is there any significance difference in the mean achievement score of boys and girls taught Technical drawing using Artificial intelligences?

Table 3: Mean of pre-test and post-test scores in achievement test of boys and girls taught Technical drawing with Artificial intelligence.

Group	N	Pre-test	Post-test	Mean difference
Boys	49	21.11	60.63	39.52
Girls	19	19.12	58.21	39.09

The data presented in table 3 show that boys taught Technical drawing with Artificial intelligences had a mean achievement score gain of 39.52 which is slightly higher than that of the control group with mean gain of 39.09. With this result, boys taught Technical drawing with Artificial intelligences performed better than girls taught Technical drawing with the same Artificial intelligences in the achievement test.

Research Questions Four

To what extent does the mean interest rating of boys differ from that of the girls taught Technical drawing using Artificial intelligences?

Table 4: Mean of pre-test and post-test scores of boys and girls taught Technical drawing with Artificial intelligence in their interest rating.

Group	N	Pre-test	Post-test	Mean difference
Boys	49	23	60	37
Girls	19	22	56	34

The data presented in table 4 show that boys taught Technical drawing with Artificial intelligence had a mean difference in interest score of 37, while the girls taught Technical drawing with Artificial intelligences had a mean gain in interest rating score of 34. With this result, the interest in Technical drawing of the boys taught Technical drawing with Artificial intelligences is higher than the interest of girls taught Technical drawing with the same Artificial intelligences.

Hypothesis Testing

HO_1: There is no significant difference between the mean achievement scores of students‟ taught Technical drawing with Artificial intelligence and those taught using conventional teaching methods.

Table 5 : t-test analysis of experimental and control group in achievement test scores

Groups	**N**	**Mean**	**St. Dev**	**Df**	**t-test**	**P**	**Remark**
Experimental	68	23.25	2.33	115	0.23	**0.01**	Significant
Control	49	21.45	2.67				

A test of significance differences was carried out at 0.05 level of significance. It shows that the p value is 0.01, it is less than 0.05 which indicate that there is significance difference between students exposed to Artificial intelligence and those that were taught Technical drawing using the conventional chalk and talk method of teaching. Therefore, the null hypothesis is hereby rejected.

HO_2: There is no significance difference between the mean interest rating of students‟ taught Technical drawing with Artificial intelligences and those using the conventional method.

Table 6: t-test analysis of experimental and control group in interest rating

Groups	**N**	**Mean**	**St. Dev**	**Df**	**T**	**P**	**Remark**
Experimental	68	25.34	2.95	115	0.56	**0.04**	Significant

Control	49	18.45	3.24

A test of significance differences was carried out at 0.05 level of significance. It shows that the p value is 0.04, it is less than 0.05 which indicate that there is significance difference between students exposed to Artificial intelligence and those that were taught Technical drawing using the conventional chalk and talk method of teaching. Therefore, the null hypothesis is accepted. This indicates that there is no significant interaction effect of treatment given to students and their gender with respect to their mean scores in the achievement Test.

HO_3: There is no significant different between the mean achievement scores of boys and girls taught Technical drawing with Artificial intelligences.

Table 7: t-test analysis of male and female group in achievement test

Groups	N	Mean	St. Dev	Df	T	P	Remark
Male	49	22.25	2.38	115	1.34	0.52	Not Significant
Female	19	20.45	2.47				

Summary of Analysis of t-test of significance shows that the null hypothesis is therefore not rejected at .05 level of significance with this result, there is no significant difference between the mean achievement scores of male and students taught Technical drawing with Artificial intelligence.

HO_4: There is no significant different between the mean interest rating scores of boys and girls taught Technical drawing with Artificial intelligences.

Table 8: t-test analysis of male and female group in interest rating

Groups	N	Mean	St. Dev	Df	T	P	Remark
Male	49	21.44	2.21	115	0.73	**0.81**	Not Significant
Female	19	20.23	2.75				

From the data presented in table 8 above, p-value is 0.81 greater than 0.05 level of significance at which the hypothesis was tested. This result implies that there is no significance difference between the mean scores of boys and girls taught Technical drawing with Artificial intelligence in their mean interest rating. Therefore, the null hypothesis was not rejected.

Discussion

The implication of this finding therefore is that Artificial intelligence is more effective than conventional teaching methods in enhancing students achievement in Technical drawing. This find is similar to the finding of Odogwu (2022) who found that there was a significant difference in the mathematics achievements of experimental group taught with computer tutorial and control group taught with conventional teaching methods in favour of the experimental group – Kulik *et al.* (2021) in their study on "Effect of computer-Based teaching on Technical drawing students' also found out that the use of Artificial intelligence in teaching Technical drawing students improved their achievement in the subject than the students taught Technical drawing with traditional instructional methods. The findings is also in line with the assertion of Cotton (2024) who pointed out that the use of computer based on learning produces achievement effects superior to those obtained with traditional instruction. Cotton explained further those students learning rate is faster with computer based learning than with conventional instruction.

This support the view of Jarvis (2018) students learn best when computer is used for instruction delivery. The author explained further that students learn better and retain more of what is taught in the class. This result showed that the effectiveness of treatments on

students' achievement in Technical drawing does not depend on the level of gender. Hence, there were no differential effects of treatments over levels of gender (Male and female), which implies that computer tutorial is more effective than conventional teaching methods in improving students' achievement in Technical drawing regardless of gender.

It has been established that the learners' own feeling toward the subject matter will largely determine how much of the material will be learned and how thoroughly it will be learned. According to Ogwos and Oranu (2016) to facilitate learning the teacher must secure and sustains the attention and interest of the learners emphasis that unless attention is maintained and interest sustained, learning can hardly be accomplished. A state of sustained interest is shown by continued and determined readiness to learn on the part of the student as evidence by a state of readiness to learn.

In summary, it was clearly revealed that the effectiveness of treatment on students and interest does not depend on gender level (female and male) and which also implies that Artificial intelligence is more effective than conventional teaching methods in stimulating students' interest in Technical drawing regardless of gender.

Conclusion

Application of computer technology to all aspect of human endeavour coupled with the need to create student-centered classroom to engage learners in their learning tasks, improve learners and consequently achievement in the school subjects has necessitated the use of computer in teaching. This study has found out the computers tutorial improves students achievement and interest in Technical drawing than conventional teaching methods.

The study also found out that no significant irrespective of gender, students studying Technical drawing will record improved performance in their achievement and interest in Technical drawing when Artificial intelligence method is used for teaching. These results therefore revealed that computer-based learning is a viable alternative to the conventional teaching methods in teaching Technical drawing.

Moreover Artificial intelligence provides powerful tools to support shift to student-centered learning and is capable of creating a more interactive and engaging learning environment for teachers and learners.

Recommendations

Based on the findings of this study, the following recommendations are made.

1. Further empirical studies should be carried out on the use of computers for instructional purposes, on different subject and at different levels to provide sound basic for the integration of computer in Nigerian schools.
2. Curriculum planners such as Nigerian Educational researches and developments council (NERDC) school consider review of curriculum for Technical drawing for secondary schools with a view to incorporating the computer tutorials.
3. Since the findings of this study showed that students who worked on the Artificial intelligence performed better than those who adopted the conventional teaching method, students should be encouraged to develop interest in the use of computer.
4. Niger state government should provide relevant equipment for teaching Technical drawing in all the technical colleges.

References

Abdulkadir, M. (2021). *Assessment of teaching-learning practices in practical motor vehicle mechanic work at technical college level in Niger State, Nigeria.* Unpublished Masters Degree Thesis, Federal University of Technology, Minna, Nigeria.

Adedeji O.A. and Mudasiru, O.Y. (2020), effects of Artificial intelligence on Technical drawing students‟ performance in Biology. The Turkish online journal of education technology 9(1)

Agwagah, H. (2024). Instruction in mathematics reading as a factor in students' achievement and interest in word problem solving. Unpublished Ph.D. thesis, University of Nigeria, Nsukka, Nigeria.

Ali, A. (2021). Key factors for determining students' satisfaction in distance learning courses: A study of AllamaIqbal Open University. *Contemporary Educational Technology, 2*(2), 118–134.

Bell, T., Urhahne, D., Schanze, S., & Ploetzner, R. (2020).Collaborative inquiry learning: Models, tools, and challenges. *International Journal of Science Education*, 3(1), 349–377

Cotton, K. (2024), Artificial intelligence, school improvement Research Series, http://www.nwrel.org/scpd/sirs/5/cu10.html

Dori, Y. (2025). A framework for project based assessment in Science education, 2025.

Federal Republic of Nigeria. (2023). *National policy on education.* Lagos: NERDC.

Jarvis, J. C. (2018). Effect of covergent thinking based instructional strategy in senior secondary school mathematics. *The Educational Psychologist*, 2(1), 150-155

Kulik, J., Corrigan, C., Nemeth, T; & Spencer, L. (2021). Improving students higher-order thinking skills in Technical drawing. *Unpublished Masters Thesis*. Wheeling, IL.

National Board for Technical Education (2021). *National technical certificate examination (craft level) syllabus for engineering trades based on the NBTE modular curricular.* Kaduna: NBTE.

Odogwu, A. (2022). Population and Technology Education: The problem of acquisition of employable skill in survival for the Nigeria education system. In Okpara, E. N. (Ed). Association for promoting quality education in Nigeria, (107-114).

Tekinarslan, T.R., Adenoyin, A. & Ajerole, K.A., (2023). Cooperation between educational institutions and enterprise in Technical and Vocational education in Nigeria: The perspective of an employer in establishing partnership in Technical and Vocational education. A seminar for key personnel from Africa and Asia, Berlin, Germany on May 2-12, 1995 by UNEVOC.

Tseng, O. V., Adamachi, B. C. & Romaine, H. A. (2020). Instruction in Technical drawing reading as a factor on Students Achievement and Interest in word problem solving. *Unpublished Ph.D Thesis*. University of Nigeria Nsukka.

SUB-THEME 5

MECHANICAL TECHNOLOGY

MECHANICAL TECHNOLOGY AND IT FUNDING FOR SUSTAINABLE DEVELOPMENT IN THE 21st CENTURY

Akpaka Stephen Andrew PhD
Department of Fabrication and Welding Engineering
Government Technical College Patigi Kwara State.
Email:akpakastephen7@gmail.com
08106573036

Abstract
This paper covers Mechanical Technology and it funding for Sustainable Development in the 21st Century. This paper examined the need for sustainable development in the 21st century, mechanical technology and it component, and the challenges facing mechanical technology in Nigeria such as, Lack of modern equipment and facilities, Shortage of qualified instructors and Limited of funding was also discussed. Recommendations of this paper include that appropriate legislative for the implementation of the national policy on Technical Vocational Education and Training should be made as a necessity in Nigeria. And adequate funding of Mechanical technology should be a priority of the government and stake holders.
Keywords: Mechanical Technology, Funding, Sustainable Development.

Introduction
Nigeria as a country had advocate for the types of education that would enhance the needed sustainable development of the learner and the society at large. Technical vocational education and training (TVET) would help in achieving the much desired sustainable development in Nigeria. UNESCO and the International Labour Organization (ILO) define (TVET) as aspect of educational process involving, in addition to general education the study of mechanical technology and related science and acquisition of practical skills, attitudes, knowledge and understanding related to occupation in various aspect of economic and social; life (UNESCO and ILO, 2001). TVET that is carried out in public and private educational institutions aimed at granting all sector of the society access to lifelong learning resource. However, Technical education is purely intellectual in all sense of design and production, though Nigeria political institution continue to minimize technical education, they under value the potential of TVET to help eradicate or reduce a significantly the gross problem of unemployment or underemployment of her citizen. The aim of TVET according to Porres, Wildemeasch and Simon (2014) is to prepare the youth of the country for work, which has to do with learning and developing work related skills of any types, integrated with entrepreneurship training for effective transfer of product and services of the learner. Skills are needed for sustainable development of individual and the country at large. Sustainable is the ability to be sustained, uphold, supported or continued so as to maintain a certain state or position. Development assuages people from low standard of living into proper employment with suitable shelter. However, development is concerned with sustainability, that is, meeting the needs of the present generation without endangers the next generation opportunities. Therefore, sustainable development should better the per capital income of people and be the major sources of a higher level of employment of people, this is because sustainable development goes clasping each other's hands with production activities (Tani and Kalus, 2019).

Sustainable developments equip one with capability to interpret things correctly and to apply the information gathered in real life. Thus, Vocational and Technical Education has emerged as one of the most effective human resource development strategies that Nigeria need to embrace so as to train and modernize the technical force work for industrialization and

national development (FRN, 2013). Nigeria is grossly blessed with two factors that determine the sustainable development of any nation, that is natural resources and population (labour) but there are lapses in physical capital investment, (infrastructure), human capital investment, technology etc. government of Nigeria must take drastic action that geared to sustainable development that depends on human capital investment on technical vocational education and training. However, the purpose of this study is to look insight on Mechanical Technology and it funding for sustainable Development in Nigeria. Mechanical technology is an aspect of TVET that has a significant role to play in the transfer of technical knowledge and skill need for work for Nigeria youth. This work is a review of such subject matters as a tool for sustainable development in Nigeria.

However, mechanical technology has to be properly funded for the sustainable development learner and the society at large. Funding is the art of proving resources a needed program or project; it is usually in form of money. It can also be in form of effort or time from an organization. In other to improve the financial situation of mechanical technology in Nigeria there is need for financial assistance and participation of private institution, religious organization and non-governmental organization to take part in funding of mechanical technology. Blueharen (2019). Viewed education as an exclusive service of the government, he further that, public always belief that funding of education is in the sole responsibility of the three tiers of government. In addition, Onuka (2014) stated that government is almost entirely the only source in funding Nigeria University education he further stated that Nigeria people are become so much used to government largesse that most of them do not want to spend anything on education. Moreover, he emphasized that the stakeholders want the government to continue to fund university education in other to fulfill it social responsibility to the citizenry and as an investment in social capital for human capacity building for who sustainable development takes place. Akinnoso (2012) in Akomolafe & Aremu (2016) also stated that many universities rely on government that the main source of financing education in Nigeria is in the hand of the government. Blueheven (2019) also opined that some people believed that the funding of education will be too cumbersome for government alone. He agitated that there should be a paradigm shift to imbibe new core value that would align with global realities of the rapid technological changes. He goes further that educational policies are not often government based that it has to do with demand which is based on the will of the people. Therefore, it is necessary for both parties to join hands in funding education not to be exclusively left in the hands of the government. However, Blueheven (2019) stated the following sources of funding in educational system: The use of Direct labour, PTA, Payment for extra lesson proceeds from the school activities, Appeal fund raising, Community involvement, Donation Alumni, Non- Governmental Organization, School fees, International organization, School activities, Community effort, Alumni contribution, Education tax fund, Rentals, State Government budgetary allocation, Grant, Endowment/Donation, Local government activities, Government agencies and Corporate effort/ activities. Akinsanya (2016) also gave the following sources of financing eg Tuition and fees, Gifts, Grants, and Endowment investment income, Auxiliaries i.e. enterprise, Parent, Alumni, Consultancies and researcher activities, Community participation, and International aid. In addition, Named & Amnesia, (2015) stated that the department can embank on project that generate additional fund like consultancy services. Furthermore, Nwapa, (2016) also suggested several ways of making additional funds like donation of money by PTA, uses of direct labour proceeds from school activities, old student donation, community involvement and non-governmental organization, the technical department can also generate money in their school. With all this method of funding, mechanical technology problem of skill exist in term of infrastructure, human resources and modern machine tool and equipment in higher institution in Nigeria. It is unfortunate situation in this country because the way and manner in which mechanical

technology is being founded is not encouraging at all, because when it comes to funding of mechanical technology the money voted for Vocational and technical education is grossly inadequate and has grossly affected the smooth running of the program. However, funding of mechanical technology in our various institutions in Nigeria is imperative.

Need for Sustainable Development in the 21st Century

Education is the key that will allow many Sustainable Development goals (SDG) to be achieved. With proper education people can break from cycle of poverty, therefore, education helps to reduce inequality and to reach gender equality. It also empowers people everywhere to live more healthy and sustained lives. Sustainable development is a circuit of fostering tolerance and contributes to more peaceful society (http://www.org/sustainabledevelopment). Funding of education is the most powerful weapon one can use to change the world and for self-enlighten. Higher education plays an important role for the student and the society in which they live. It represent the growth of an individual which assuring him or her to lead a better life as there are more chance of getting a highly paid job, in turn the society will benefited as the ideal citizens are created who will keep the society peaceful. The need to foster sustainable development that will cater for the needs of it large population and imperative for proper integration of it domestic economy into the world economy in the face of increasing globalization. Advancing good democratic governance is key to political stability of the country. The basic needs of the people, that is, inadequate and inefficient infrastructure and development are critical issues that government needs to address. The government also recognized the need to maintain the sustainability of the country resources for the benefit of present and future generation. The strategic approach that is adopted to operationalize sustainable development in Nigeria centers on critical mechanism such as, Governance, education, Capacity building stake holders, Information and communication technology (ICT), Environmental monitoring and due management, science, technology and innovation, Research development financing for sustainability, and interaction and regional co-operation (FRN 2012). All the factors of sustainable development mentioned above geared toward social engineering, preparing and equipping people to become self reliance and good interpersonal social relationship that enhance productivity, innovation and positive engagement of citizens for peaceful and harmonious living. However, the good intentions of government concerning the above mentioned factors that determine the success of any government for her people has so far in Nigeria failed to deliver the so call desired. Proper founding in education also helps to provide graduate with basic knowledge and understanding about economic activities that occur worldwide. A country that posses such people would be safe to be termed as a literate country. British council (2014) stated that graduate and internship student do interact with the society to share knowledge, help the nation in making decision and coming up with new ideas of doing things better, increases the productivity of the nation thereby improving it economy. The graduate with expertise in a certain fields would be in a better position to be leaders in their particular field of expertise. Sub-system in modern mechanical, intended to improve upon their safety, economy, and comfort among other things have made them more sophisticated and complex to maintain (Odigin & Okafor, 2018)

Therefore, proper funding of education produces ideal leaders, the consistent development and quality of mechanical teacher in mechanical technology will improve the capability of mechanical teacher for efficient use of the curriculum, As such there is need for sustainable development programs and an adequate supply of human material resources for educational productivity and consolidation of the Nigeria educational system (Adebile & Foluke, 2019). The need for sustainable development required that our technical colleges and vocational and technical institutions should lay the ground work to meet both the demands of industry and the need of the mechanical technology student. The need for sustainable development requires

train and retrain mechanical technology teacher especially automatic transmission who are being promoted is self- evident, every job usually requires training in new skills. For effective productivity of quality mechanical teacher and consolidation of Nigeria educational system, teacher in mechanical technology must be effectively trained and retrained (Askinbote, 2018).

Mechanical Technology and it Components

Technical education offered in Nigeria educational system are building technology, wood work technology, drafting technology / technical drawing, electrical/ electronic technology, industrial craft, auto mechanic / automobile technology, metal work technology. Mechanical technology is an integration of auto mobile and metal work technology. Mechanical technology therefore, can be divided into two broad groups of area generally referred to as metal production and the automobile system options. Several occupations are made of each of these options that required specialized training. In metal work technology option it comprises of foundry or metal casting, welding and fabrication, sheet metal work, structural steel work, and fitting and machining. In automobile technology option we have panel beating and car chases designers, motor engine block designers and production, auto-electrician and auto air conditioning work. According to Atsumbe, Okoro & Ogwo (2012) and Peter, Abiodun & Jonathan, (2010) in Akpaka, (2023) mechanical technology trade is general name used in describing trades that have direct bearing with metal welding / forming and servicing/ repair of machine or machine related equipment and appliances. The trade in this group include agricultural and equipment mechanic work, auto-body building, auto parts merchandising, air conditioning and refrigerator mechanic work, foundry craft practice, fabrication and welding engineering craft practice, instrument mechanic work, marine engineering craft and mechanical engineering craft practice. However, mechanical technology trades have a variety of job opportunities. Usoro, Mathiew, and Udofia (2019) opined that there are job opportunities in automobile mechanic work such as engine cleaning, lubricating auto systems and repair front end service job, auto body repairs, auto shop management, service station management, spray painting, auto interior upholstery, chases repair job, vulcanization, radiator repair job, crankshaft cutting, mechanic driver, engine building/services, wheel alignment and tire balancing and the new use of On-Board Diagnosing machine. In the metal work technology it provide jobs like machining career, welder, fitting job, welding analysis, welding technicians, metallurgist, welding shop management, foundry work, welding and fabrication job, and welding instructor. However, mechanical technology is a critical field of study that has the potential to create job opportunities for millions of the teeming unemployed youth in Nigeria. Therefore, mechanical technology has to properly fund in our various institution that offered mechanical technology.

Challenges Facing Mechanical Technology in Nigeria.

Lack of Modern Equipment and Facilities.

Vocational and technical education can not contribute immensely to the reduction of object, poverty, hunger, and unemployment because of it numerous challenges. The ever changing role of teaching especially mechanical technology demand professional teacher not only by name but also in training and status in the society. Most of the TVET department in our higher institutions do not have well equipped laboratories, workshops and usable infrastructure, where these exist they are grossly inadequate, absolute and in a dilapidated state. Indication shows that only 40% of tertiary institution in Nigeria have laboratory workshop spaces for TVET program in the remaining 60% of other institutions do not have laboratories or workshops spaces and this affects the low quality of mechanical technology program in higher institution (Dokubo, 2013). According to Goro (2017) teachers must be provided work and have access to the necessary technological equipment and resources that will result in enriched student learning. Therefore, the teacher in training needs quite a good numbers of infrastructure and educational facilities such as machine tools, equipment and

tools. Mechanical technology teachers need to be provided with good recreational facilities for their physical and social development (Akpaka 2024). Lack of modern equipment and facilities is one of the major problems hindering the progress of mechanical technology in Nigeria, lack of access to modern equipment and facilities with proper tools resources students are unable to gain the practical skills and experience necessary to succeed in their field. Moreover, inadequate workshop with outdated machinery, lack of access to computer aided design software and insufficient laboratory equipment for hands- on learning is the major road block hindering the progress of mechanical technology in Nigeria (https://discipline.ng/automobile-technologyeducation). The important of facilities and equipment to the overall success of any educational program can never been in doubt. Umar, (2008) in Akpaka (2024) stated an emphasizes on the need for provision of adequate facilities equipment for the effective teaching and learning process. Moreover, Idris (2012) maintained that equipment and facilities needed for effective instruction of mechanical technology should be a replica of what is obtained in mechanical technology laboratory or workshop. The need for available of functional equipment and facilities such as modern laboratory, machine, computer diagnosing scanners and tool can never be over emphasized. However, with the effective utilization of equipment and facilities student interest will be greater in learning system and it will also enhance retention of learned ideas.

Shortage of Qualified Instructor

Another critical issues facing mechanical technology is inadequate of qualified personnel, and without experienced and knowledgeable teacher, students are unable to receive the guidance and mentorship they needed in their studies. Training is a visualized as the acquisition knowledge, skills, technique, attitude and experience which enable individual to make effective contribution to the combined effort of team in the transfer of service. The Federal Republic of Nigeria (2013) acknowledged that no education system can be better than the teacher itself. To get quality mechanical for sustainable development, the person operating it must be well knowledgeable to be able to impact same to the student. According to Isa (2016) teachers who are occupationally qualified and competent in their subject area contribute immensely to the success of educational program in their area of specialization. Therefore, mechanical technology in every of our various institutions need qualified and adequate teachers for sustainable development in Nigeria,

Limited Funding

Mechanical technology has made some notable impacts on the Nigeria society especially in respect to the products of training program who are contributing their quota to the economic growth and development of the nation. In Nigeria today, there is several poor funding for project initiative, this preventing the technical and vocational institution from making significant progress. Funding of technical and other vocational institution in Nigeria is nothing to writes home about and this invariably affecting the procurement of the required equipment and facilities for mechanical technology in our various institutions. Inadequate funding of mechanical technology in our various institutions has caused the turning out of half baked graduates due to limited fund to build and maintain workshops, laboratories or even purchaser modern equipment. Ma'aji, Ohize & Tsado, (2010) stated that poor funding causes acute shortage tools, machine, facilities, and sizeable laboratory for mechanical technology program. For mechanical technology program to be effective as it found in most developed countries there should be adequate and appropriate funding both the government and stakeholders. This would enhance the procurement and provision of equipment, facilities and adequate manpower development in mechanical technology. Moreover, several lack of funding for research projects and initiative preventing the industry from meeting significant progress. Poor investment in innovative technology and practice, low government support for research in mechanical technology sector and challenges in securing grants and funding for

research project (https://discipline.ng/automobile-technologyeducation). Addressing these challenges crucially there will be growth and development in Nigeria. However, by investing in modern equipment, having qualified personnel and providing adequate funding on research and development the country can create a thriving environment for student to learn and excel in the field of mechanical technology.

Conclusion,

The challenges of Nigeria lies in the key issues of sustainable, which geared toward social engineering preparing and equipping people to become self reliance and good inter-personal and social relationship that enhance productivity, innovation and positive engagement of citizen for peaceful and harmonious living which lies in the use of technology such as the field of mechanical technology to provide millions of jobs create massive employment for the people and enhancing a better society and a peaceful nation. In addition, technological advancement have provided comfort and joy to life. However, mechanical technology has a direct and vital impact on the quality life for all citizens, therefore, mechanical technology in our various institutions in Nigeria as to be properly funded.

Recommendations

The following recommendations were draw out

1 Appropriate legislation for the implementation of the national policy on TVET should be made as a necessity in Nigeria.

2 Adequate funding of mechanical technology should be a priority of the government and stakeholders. Inadequate fund affect the provision of essential resources, such as well equipped workshops and laboratories, relevant textbooks and training manuals.

3 Government should implement a policy on computer education that would provide training of mechanical technology educators who will well placed in training the learners for new jobs that are occasion by automated equipment and devices.

4 There is the need for our technical and vocational institutions to establish good relationship and linkages with similar institutions abroad this will promote cross-fertilization of ideas and enhance technology transfer. By so doing the technical and vocational institution will have access to new development, exchange programs and other numerous benefits.

REFERENCES

Adebile, Ruth Funke (2019). Curriculum Implementation and Retraining of Teacher in English Language: Pre-condition for functional Nigeria Educational System. *An International Multi-Disciplinary Journal, Ethopia.Vol.3 (2)* ISSN 1994-9057 (print) ISSN 2070-0083 (online) (pp.287-295

Akinbote, O A. (2018). When faculty use instructional technology (Information and Communication Technology): Using Clark's delivery model to understand gender difference. *The Canadian Journal of Higher Education 32 (1), 31-56*

Akinoso, N. (2012). Tackling the Shortage of fund. Retrieved from www.punch.ng.com. On 21 /4/ 2014.

Akinsanya, O. O. (2016). Financing Higher Education in Nigeria. Retrieved from hhps://ojc.sire.edu. On

Akomolafe, C. O. & Aremu, E. T. (2016). Alternative Sources of Financing University Education in Lagos State Nigeria. doi:10.19044/esj.2016.v12n34p284. URL:http://dx.doi.org/10.19044/esj.2016.v12n34p288.

Akpaka. S. A. (2024). Strategies for Enhancing Automobile Teachers' Education for Quality and Sustainability. *INDUSTRIAL TECHNOLOGY EDUCATIONAL RESEARCH JOURNAL,* 7 (2) 64-74, https://iterj.org/pub/article/riew/43

Akpaka, *S. A.* 2023. Work-life conflict, ergonomics principles and *professional* commitment as correlates of job satisfaction among mechanical engineering craft practice teachers

in technical colleges north central state *Nigeria.(Unpublished Doctoral Dissertation),* University of *Nigeria.* Nsukka.

Atsumbe, B. N., Okoro, O. M., and Ogwo, B. A. (2012). Practical Skill Improvement Needs of Technical College Mechanical Engineering Craft Practice Curriculum in Nigeria. *Journal of Education and Vocational Research. 3*(4), 118-126.

Bluehaven, M. (2019). Sources of Funding Education in Nigeria. Retrieved from https://www.nairaland.com517996... On 19 may 2025 at 5.10pm.

British Council (2014). Can high education solve Africa's job crisis? Available on, hhp://wwwBritishCouncil.org/sites/britishcounciluk2/files/graduate-employability-in-ssa-finas-web.pdf.

Dokubo. C. & Dokubo, I. (2013). Identifier Problem Inhibiting the Effective Management of Vocational Education Programs in Nigeria University. *European Scientific Journa, 9 (22), 185 – 174.*

Federal Government of Nigeria (FGN) (2013). National policy on education Lagos: (6th Edition). Lagos: Nigeria educational research and development council (NERDC) press.

Federal Republic of Nigeria (2012). Country Report to the Riot 20: Nigeria Part to the Sustainable Development through Green Economy, Federal Republic of Nigeria. Abuja.

Goro, C A. (2017). Technical Teachers Production utilization in the Nigeria secondary Schools Education: Relevance for developing skills of Craftsmanship and the Humanistic Discipline, Unpublished.

Idris. A. M. (2012). The Level of Availability of Recommended Tools and Equipment for Teaching Motor Vehicle Mechanic Work for Sustainable Industrial Development in Nigeria. Proceeding of the 24th Annual National Conference of the Nigeria Association of Teacher of Technology

Isa, K O. (2016). Vocational Education programmes in Nigeria: Issues and Challenges. *Journal of Technical Education. (1) p. 45*

Ma'aji. A. S, Ohize. E. J., Saba. T. M. and Tsado. J. (2010). Assessment of the implementation of students industrial practice in engineering and technology education programs in the university in northern Nigeria. *Journal of Educational Research and Development. ABU Zaria 5 (3) 194-200*

Named, M. and Amnesia, J. (2015). Funding business education programmers for Sustainable development in Niger-Delta. Research in Humanity and Social sciences.

Nwapa,P. (2016). Alternative sources of financing secondary education in Ebony State by Administrators British Journal of Education 4 (4); 10-14)/

Odigiri A. M & Okafor E. E, (2018). Department of Vocational Teacher Education, University of Nigeria, Nsukka, Nigeria.

Onuka, A. O.U (2014). Funding the Nigeria University Education: The Role of various Stakeholders Retrieved from www.herp.nert.org On 21 /4 /2014.

Overview of Automobile Technology Education in Nigeria. Available on, https://decipline.ng/automobile-technologyeducation. Last updated on June 12 2024

Peter, O. I., Abiodun, A. P. and Jonathan, O. O. (2010). Effect of Constructivism Instructional Approach on Teaching Practical Skills for Mechanical Related Trade Students in Western Nigeria Technical Colleges. *International NGO Journal. 5*(3), 59-64.

Porres, G. T, Wildemeersch, D. & Simon, M. (2014). Reflection on the emancipator potential of vocational education and training practices : Frame and Ranchero in dialogue. Studies on continuing education, 36 (3). 275-289.

Quality Education: Why it Matters. Available on, http://www.org/sustainabledevelopment

Tani, V. & Kalu, E. O. (2019). Mechanical Technology Education for economic Growth, Development and Society Stability. *Global Scientific Journal Volume 7 issue 10, online: ISSN 2320-9186 www.globalscientificjournal.com.*

Umaru. I. Y. (2008). Management of technical college's workshop for improved practical skills acquisition in north central State of Nigeria. Unpublished M. Tech. Project . Department of industrial and technology education. Federal University of Technology. Minna.

Usoro, H, Mathrew, P. U, & Udofia A. E. (2009). Technical Education for Job Creation and Sustainable National Development in Nigeria. *Journal of Teacher Perspective, (1) 66-76.*

MISCONCEPTIONS AMONG METALWORK TRADE STUDENTS IN GOVERNMENT TECHNICAL COLLEGES IN KANO STATE: TRACKING MISCONCEPTIONS USING ChatGPT

ABUBAKAR ADAMU NJIBULWA, anadamu.ste@buk.edu.ng , 08038610426
BAYERO UNIVERSITY KANO. FACAULTY OF EDUCATION, SCIENCE AND TECHNOLOGY EDUCATION DEPARTMENT, PMB 3011, KANO STATE, NIGERIA.

Abstract

Technical Vocational Education and Training (TVET) is a comprehensive term that refers to those aspects of the education process involving in addition to general education, involving the study of technology which dealt with the acquisition of practical skills, attitudes, and knowledge in relating to occupations such metalwork trade. Misconceptions tend to be stable, resistant to change, and very problematic to the students. Due to their strength and flawed content, misconceptions also interfere with students' learning of the correct understanding of technical concepts. Example, 'Boss' which means rounded projection on the outside of the cast metal, confused with 'Boss' that is principal officer in the organization. The objective of the study was: 1) To find out the mean score of rural and urban students in misconceptions in metalwork trade. 2) To find out the mean scores NTC I, NTC II and NTC III students in misconceptions in metalwork trade among metalwork trade students in technical colleges of Kano State Nigeria.Two research questions were raised: 1) Is there any difference in mean score of rural and urban students in misconceptions in metalwork trade? 2) Is there any difference in mean score of NTC I, NTC II and NTC III students in misconceptions in metalwork trade? The survey research design was use for the study. Two Hypothesis were formulated as, Ho_1: There is no significant difference between the urban and rural students' performance students in misconceptions in metalwork trade. 2) Ho_2: There is no significant difference between NTC I, NTC II and NTC III students' performance in misconceptions in metalwork trade. The area of the study comprises of 5 Senior Technical colleges of Kano State. Purposive sampling was used to select four Technical colleges. The target population of the study was 210 NTC I, NTC II, and NTC III Metalwork trade students. Purposive sampling was use to select 129 NTC I, NTC II and NTC III Metalwork trade students. NABTEB pass question papers was adopt as the instrument for data collection. The data was analyses using SPSS. The findings of the study indicated that the mean score of rural students was 6.304 and the mean score of 7.759 of urban students in misconceptions in metalwork trade. Some of the recommendation includes; Teachers should devote more time in explanations and definitions of some misconceptions so that students will be familiar with them. Students should be taught to use appropriate concept in describe and explain metalwork trade concept. Teachers should use visual representations of the words in order to assist students' understanding metalwork trade. Tracking Misconceptions using ChatGPT as a tool to address misconceptions among metalwork trade students presents an innovative way forward. ChatGPT could serve as a powerful resource to correct misunderstandings, enhance learning, and provide continuous support to metalwork students.

Key words; misconceptions, Metalwork, Trade, Technical Education

Introduction

Technical Vocational Education and Training (TVET) is a comprehensive term that refers to those aspects of the education process in addition to general education, involving the study of technology which dealt with the acquisition of practical skills, attitudes, and

knowledge in relating to occupations such metalwork trade. Metalwork trade according to Arikpo, *et al,* (2022), is the application of knowledge in the activity of making objects out of metal artistically and skillfully. In other words, it is the totality of all the processes involved in the production of metal articles. Metalwork trade consists of; foundry, forging, welding and fabrication, sheet metal work, machine shop practice (metal machining), and metallurgy. The metalwork trade aims at providing the labor market with qualified workers who could work successfully with modern production technologies in metalwork industries.

However, these aims could be related to the pedagogical skill of the teacher's ability to implement pedagogical interaction that will help the students understand concepts in metal work trade, which are related to the industrial usage. The pedagogical approach should be among the prescribed learning theories, such as constructivist learning theory, which states that students come to the learning environment with preconceptions, which occur during their interactions within the physical and social environment, and those preconceptions affect students' learning. These preconceptions lead to students' misconceptions in learning. Studies revealed that misconceptions emanate from students' different cultures, religions, and languages, which are frequently similar or different from the English language. Misconceptions may deeply penetrate students' minds and resist change (Olaitan and Asogwa, 2023). Thus, learning could only take place if there is a behavior change. Misconceptions could be, in some cases, parallel to the explanations made by the teacher. Moreover, Daniel et al (2020), viewed that inadequate resources are not the only factor hindering the effective teaching and learning of metalwork trade; factors such as misconceptions, or incorrect and incomplete understandings of metalwork concepts, represent another significant challenge. Misconceptions occur when students hold beliefs or explanations that contradict technical meaning, often due to inadequate prior knowledge, poor teaching methods, or cultural influences.

Furthermore, Mumuni et al (2022) conducted a study on misconceptions among 550 Level 100 students of First-Year students at Bagabaga College of Education on the Visual Arts and Technical Education aspects of the Foundations of Social Studies and Technical Vocational Education and Training (FFSSTVET) subject. It was found that students had different ideas about the nature of Visual Arts and Technical Education at the Colleges. Adamu et al (2024) examined the determinants of misconceptions of vocational and technical education programmes among 342 candidates of the Unified Tertiary Matriculation Examination (UTME) in Yobe state, Nigeria. The study, concluded that the general misconception on vocational and technical education programmes has a negative effect on the attitude and interest of UTME candidates towards the programme in Nigeria. The study recommended, among others, that students should be educated on the importance of vocational and technical education programmes, and the Yobe state government should initiate orientation programmes that would educate potential UTME candidates on the importance of vocational and technical education in Nigeria. Daniel et al (2020) conducted a study comparing the knowledge, presence of misconceptions, and critical thinking ability of vocational education and training (VET) fitness students at the beginning and end of their training, and qualified personal trainers (PTs). It also examines differences in the sources of information used by students and professionals. VET students' knowledge improved, and misconceptions decreased from pre- to post-training. Thus, the information varies and, with the application of skills, may result in misconceptions forming.

Moreover, it is of paramount importance for teachers in TVET, most especially in the metalwork trade. For example, concepts like; a)'Boss', which means 'rounded projection on the outside of the cast metal', is often confused with 'principal officer in the organization'. b)'Operations' in metal machining are often confused with medical surgery. c) 'Lead' is a metal, which is often confused with leading people. d) 'Die' in metal forming (in Hausa

language refers to 'Mutuwa'), somebody's end of 'life'. e) 'File' is used for smoothed/thickness reduction of metal surface, confused with the office 'file.' f) 'Plates' used in holding pieces of metal are confused with kitchen utensils, g) 'Draft' **'**turning', 'feed' 'Tolerance', 'mandrel', 'drawing down', 'lathe dog', 'Normalizing,' among others, students may confuse with the common meaning, which is more familiar with and misunderstanding or failing to grasp the concept as it is used in the metalwork trade. These misconceptions are particularly problematic in the metalwork trade as they can interfere with the learning of more advanced topics in the metalwork course, making it difficult for students to progress in their studies. If these misconceptions are not addressed early, they can persist, affecting students' academic performance and their interest in pursuing further studies or careers in the metalwork trade.

Despite these problems there is no much research conducted that directly examines the misconceptions in the metalwork trade at technical colleges. Most of the studies conducted in the metalwork trade were focused on assessing the performance of job-specific tasks rather than students' deep knowledge or understanding of metalwork concepts (Jolley, 2019). The conditions for misconceptions to exist in the metalwork trade are certain, due to the nature of the course, which are practical-oriented course with different concept application/usage from the craftsmen's view, which in most cases differ in theory and training based on school application /usage. Moreover, according to the chief examiner's report (2012), National Business and Technical Examinations Board (NABTEB), indicated misconceptions among students in the metalwork trade, including the wrong usage of metalwork concepts. This leads to weak or poor performance in the metalwork trade. Hence, based on these backgrounds, there is a need to investigate misconceptions among students in the metalwork trade.

1.2 Objectives of the study

1) To find out the mean score of rural and urban students in misconceptions in the metalwork trade.
2) To find out the mean scores NTC I, NTC II and NTC III students in misconceptions in the metalwork trade.

1.3 Research Questions

1) Is there any difference in mean score of rural and urban students in misconceptions in metalwork trade?
2) Is there any difference in mean score of NTC I, NTC II and NTC III students in misconceptions in metalwork trade?

1.4 Hypothesis

Ho_1: There is no significant difference between the urban and rural students' performance students in misconceptions in metalwork trade.

Ho_2: There is no significant difference between NTC I, NTC II and NTC III students' performance in misconceptions in metalwork trade.

1.5 Methodology

The survey research design was used for the study. The survey design is concerned with people, their beliefs, opinions, motivation, and behavior by collecting and analyzing data from the sample (Sambo, 2005). The area of the study comprises of 5 Senior Technical colleges of Kano State (Nasarawa, Ungogo, Danbatta, Tiga, and Bagauda). A stratified sample was used to select 5 out of 32 Technical colleges. The target population of the study was 210 NTC I, NTC II, and NTC III Metalwork trade students. Purposive sampling was use to select 129 NTC I, NTC II and NTC III Metalwork trade students. NABTEB pass question papers were adopted as the instrument for data collection. Purposive sampling is a sampling technique in which the researcher relies on his or her own judgment when choosing members of the population to participate in the study (Sambo, Ibid). Thus, the researcher only considers the schools that offer General Metalwork Trade. The instrument used for data collection is the

objective Type NABTEB fast question papers. Twenty (20) questions were selected that are related to the misconceptions in the metalwork trade. The objective questions were subjected to validation by an expert. Copies of the questionnaire were distributed to respondents with the help of a research assistant. The mid- point scored was 8 marks out of score of 20 marks. That is score of 8marks and above is pass marks while score below 8marks is fail. The data was analysed using SPSS soft ware which includes T- Test, ANOVA and Tukey HSD Post hoc Test's.

1.6 Data Analysis and Results

Research Question One: Is there any difference in the mean score of rural and urban students in misconceptions in the metalwork trade?

Table 1: Mean score of rural and urban students in misconceptions in metalwork trade.

	Location	N	Mean	Std. Dev.	Mean Difference
Performance	Rural	46	6.304	2.7315	1.455
	Urban	83	7.759	2.0754	
Total		129			

Table 1: above shows the mean score of rural students in misconceptions in metalwork trade is 6.304 with standard deviation of 2.7315. The mean score of urban students in misconceptions is 7.759 with standard deviation of 2.0754. There mean difference of 1.455.

Research Question Two: Is there any difference in mean score of NTC I, NTC II and NTC III students in misconceptions in metalwork trade?

Table 2: Mean score of NTC I, NTC II and NTC III students in misconceptions in metalwork trade

	School		Mean	Std. Dev.	Mean Difference
Performance	NTC I	NTC II	6.467& 7.652	2.2115&2.4875	1.1855
		NTC III	7.658	2.4193	1.1912
	NTC II	NTC III	7.652& 7.658	2.4875&2.4193	.0057

Table 2 above shows the mean score of NTC I, NTC II and NTC III is 6.467, 7.652 and 7.658 with their standard deviation 2.2115, 2.4875 and 2.4193 respectively. The mean difference between NTC I, NTC II and NTC III is 1.1855, 1.1912 and .0057

Hypothesis One: There is no significant difference between the urban and rural students' performance students in misconceptions in metalwork trade.

Table 3: Summary of t-test Results on Significant Difference in Performance between Rural and Urban Students

	Location	N	Mean	Std. Dev.	t-test	Df	P< Value	Decision
Performance	Rural	46	6.304	2.7315	-3.398	127	0.001	Ho Rejected
	Urban	83	7.759	2.0754				

Level of significance 0.05

Table 3 shows that the P< Value is 0.001 which is less than 0.05. Therefore, the null hypothesis is rejected. Thus, there significant Difference in Performance between Rural and Urban Students

Hypothesis Two: There is no significant difference between NTC I, NTC II and NTC III students' performance in misconceptions in metalwork trade.

Table 4a: Summary of ANOVA Results Significant Difference in Performance between NTC I, NTC II and NTC III Students

	Location	N	Mean	Std. Dev.	F	Df	P< Value	Decision
Performance	NTC I	45	6.467	2.2115	3.669	2	0.028	Ho Rejected
	NTC II	46	7.652	2.4875				
	NTC III	38	7.658	2.4193				
Total		129						

Level of significance 0.05

Table 4a shows that the P<Value is 0.028 which less than 0.05. Therefore, the null hypothesis is rejected. Thus, there significant Difference in Performance between NTC I, NTC II and NTC III Students.

There is significant difference and the difference is indicated between NTC I and NTC II in the post hoc test in Table 5.

Table 4b: Summary of Tukey HSD Post hoc Test's Results

School	School	Mean Difference	P< Value	Decision
NTC I	NTC II	-1.1855	.049	Significant at the 0.05 level of Sig.
	NTC III	-1.1912	.063	Not Significant
NTC II	NTC III	-.0057	1.000	Not Significant

Result from Table 4b indicates that a significant mean difference exists between NTC I and NTC II. P<Value of 0.049, which has the same level of significance value 0.05.

1.7 Findings and Discussion

The result of Table 1 shows that the mean score of rural students in misconceptions in metalwork trade is 6.304, which is less than the midpoint of 8 marks that indicating a failure. This may be because the students are more conversant with their mother tongue as suggested by. UNESCO (2003), cited in Makikoki et al (2008) stated that there is a strong necessity for developing countries to establish an appropriate set of concepts to enable local people to learn metalwork trade efficiently throughout their educational programs. Instruction in the mother tongue is beneficial for students to acquire a basic concept in the metalwork trade. Even though urban students pass with a mean score of 7.759, which is 8 marks. The performance score was weak. Thus, the misconceptions are certain because of the similar meaning from the common meaning, which is more familiar to them. These misconceptions make understanding more difficult for students. These findings are in line with Kempa (1991), who states that some of the causes of students' learning difficulties include communication problems arising from misconceptions about technical education with context-specific specialized meanings.

Table two indicated that the differences in mean score of NTC I with a mean score of 6.467. This shows that NTC I had failed with a mean score less than the mid-point pass of 8marks. But NTC II with a mean score of 7.652 and NTC III with a mean score of 7.658, which is equal to 8marks, are the passing marks. The difference in mean score could be a result of the syllabus coverage of the metalwork trade by the metalwork trade teachers. Thus, NTC I had less coverage of the course content than NTC II and NTC III.

1.8 Recommendation: Tracking Misconceptions metalwork trade Using ChatGPT

Tracking Misconceptions in metalwork trade**:** ChatGPT could track recurring questions or misconceptions and offer tailored resources or explanations to help metalwork students better grasp the correct information. Using ChatGPT as a tool to address misconceptions among metalwork trade students presents an innovative way forward. ChatGPT could serve as a powerful resource to correct misunderstandings, enhance learning,

and provide continuous support to metalwork students and educators. Below are some alternative solutions or ways forward for using ChatGPT to tracking misconceptions:

A) Instant Query Resolution: Metalwork trade students could use ChatGPT to ask questions at any time and get immediate answers. This could help them correct misconceptions they might have during their studies. By offering explanations, step-by-step guides, or addressing common errors, metalwork students could clear doubts about the metalworking techniques, tools, and processes.

B) Text-Based Simulations: ChatGPT could be used to create interactive problem-solving scenarios for metalwork students. For example, ChatGPT can simulate real-world metalworking tasks or troubleshooting exercises, allowing metalwork students to engage in scenario-based learning to better understand how to handle different metalworking challenges.

C) Virtual Skill Development: Although ChatGPT cannot physically demonstrate all the metalwork processes but it can explain concepts in detail and guide metalwork students through complex procedures (e.g., welding, machining, forging, etc.) via step-by-step breakdowns, assisting them in visualizing and understanding these processes.

D) Personalized Guidance: ChatGPT could serve as a personalized tutor by adjusting the explanations based on each metalwork student's level of understanding. For example, if a metalwork student is struggling with the basics of welding, ChatGPT could provide foundational explanations before moving on to more advanced topics.

E) Facilitate Peer Discussions: ChatGPT could facilitate discussions between metalwork students by helping them articulate their thoughts more clearly. For instance, metalwork students can input their understanding of a metalworking technique, and ChatGPT can provide feedback or further elaboration to ensure accuracy.

F) Correcting Cultural and Societal Misconceptions: Dispel Gender and Cultural Stereotypes: ChatGPT could offer guidance on addressing stereotypes among metalwork students in the metalworking industry. It could provide stories of successful female metalworkers, discuss the benefits of diversity in metalwork trade skills, and challenge cultural perceptions that may discourage certain individuals from entering the metalwork field.

G) Incorporating Industry Trends and Updates: ChatGPT could keep students updated on the latest trends, technologies, and standards in the metalworking industry. Discussing modern tools, machinery, and automation in metalworking it could help bridge the gap between what students may believe the industry to be and the reality of its evolving nature.

H) Access to Industry Experts: ChatGPT could provide insights into the latest industry metalwork practices through virtual interviews, research summaries, and case studies from the metalworking field. This could help metalwork students understand fully how the metalwork trade works in contemporary settings and as such combat the misconceptions among metalwork students.

1.9 Conclusion

In conclusion, the misconceptions among metalwork trade students will invariably affect their academic performance in the general metalwork trade. It is therefore imperative for technical teachers in metalwork to establish a new approach in teaching metalwork concepts by a structured, integrated knowledge base on the job-oriented usage of basic concepts in the metalwork trade through the use of an Artificial Intelligence AI tool such as ChatGPT. Teachers teaching metalwork subjects should also evaluate misconceptions among students by the end of the given lesson. Teachers should use visual representations of the concepts to assist in understanding the basic concepts in the metalwork trade. Teachers should also devote more time in explanations and definitions of some basic concepts so that the

students will be familiar with them in order to avoid misconceptions in the metalwork trade among metalwork trade students. Students should be taught to use appropriate concepts in describe and explain technical concept metalwork trade.

Reference

Adamu, A., et al. (2024). Determinants of Misconception of Vocational and Technical Education Programmes Among Candidates of Unified Tertiary Matriculation Examination (UTME) in Yobe State, Nigeria. *Multidisciplinary Journal of Vocational Education & Research, 6*(1), 73-82. ISSN(Print): 2630 – 7081.

Arikpo, et al. (2022). Instructional Model for Teaching Metalwork Trades in Technology-based Education: An Empirical Evidence from Nigeria. *Journal of Positive School Psychology, 6*(3), 1950–1963.

Daniel, et al. (2020). Misconceptions in the knowledge of vocational fitness students and graduates. *Australian Journal of Adult Learning, 60*(1).

Olaitan, S. E., & Asogwa, C. I. (2023). Teacher training and its impact on students' misconceptions in science subjects. *Nigerian Journal of Science Education, 14*(2), 101- 114.

Jolley, D. (2019). *Misconceptions and Critical Thinking Ability In Undergraduate Exercise Science Students, Vocational Fitness Students, and Exercise Professionals*. [Unpublished doctoral dissertation]. Curtin University

Kempa, R. F. (1991). Students' learning difficulty in science. Causes and possible remedies. *Online Journal Ensenanza de Las ciencias, 9*(2), 119-128.

Mumuni, et al. (2020). Students' Misconceptions about Visual Arts and Technical in the Study of SSTVET in Bagabaga College of Education, Tamale. *Social Education Research, 1*

Makiko, et al.(2008). Technical Terminology in Asian Languages: Different Approaches to Adopting Engineering Terms. *The 6th Workshop on Asian Language Resource*.

National Business And Technical Examination Board. (2015). *Chief examiners report November/December NBC/NTC/ANBC/ANTC Examination*. National Business And Technical Examination Board.

Sambo, A. A. (2005). *Research method in education*. Stirling Horden Publishers (Nig) Ltd.

UTILIZATION OF ARTIFICIAL INTELLIGENCE IN MECHANICAL TECHNOLOGY EDUCATION PROGRAMMES FOR SUSTAINABLE EMPLOYABILITY SKILL DEVELOPMENT IN TERTIARY INSTITUTIONS IN RIVERS STATE

[1]AJIE, PRINCE MADUABUCHUKWU (Ph.D), [2]OJOBAH, LUCKY OBULOR (Ph.D), & [3]OKIRIE OGARANYA

[1, &2]Department of Metalwork Technology, Federal College of Education (Technical), Omoku, River State

[1]E-mail: ajiemiprince@gmail.com (07086099931)

ORCID iD; https://orcid.org/0009-0009-1540-6924.

[2] lustyztestimonies@yahoo.com. (08064656358)

[3]Department of Mechanical Technology Education. Ignatius Ajuru University of Education Rumuolumini, Port Harcourt, Rivers State.

ABSTRACT

This study examined utilization of artificial intelligence in Mechanical Technology Education programmes for sustainable employability skill development in tertiary institutions in Rivers State. A descriptive survey design guided the study, with two purposes and research questions raised, and two hypotheses were tested at .05 level of significance. The population of the study consisted of 108 year 1-IV Mechanical Technology Education students and 36 lecturers from the two tertiary institutions owned by the Rivers State government, that offer Mechanical Technology Education programmes. A sample of 48 year-three students and all 36 lecturers was selected for the study. The researchers collected data using questionnaires, which were validated by two lecturers. The reliability coefficient, determined using Cronbach Alpha Reliability Coefficient, was .84. Mean scores were used to answer the research questions, while standard deviation determined the homogeneity of responses. Z-test was used to test the hypotheses at a .05 level. The study found, among other things, that artificial intelligence is not being utilized for instructional delivery or workshop activities in Mechanical Technology Education programmes for sustainable employability skill development in tertiary institutions in Rivers state. It was recommended, among other things, that Mechanical Technology Education lecturers should undergo intensive training to acquire skills in AI package applications development for effective Mechanical Technology student employability skill development in tertiary institutions in Rivers State.

Keywords: Mechanical Technology Education Programmes, Utilization of Artificial Intelligence, Sustainable Employability skill Development.

Introduction

The modern education system has significantly expanded beyond traditional classroom limitations, enabling global participation. By leveraging digital platforms, it has attracted diverse students and teachers to technology-based learning. Free from any kind of limitations of time, space or number of students, the popularity of digital activities is increasing day by day.

According to Okparaeke, in Abel (2021), Mechanical technology education, being one of the vocational and technical education programmes offered in higher institutions, aims to produce mechanical technicians for production industry self-reliance. Mechanical technology education is an education for practical skills. It is any form of training aimed at producing skilled personnel for employment, self-reliance, and to contribute meaningfully to national development. In corroborating this assertion, Ajie, Ojobah, & Onyeaju, (2024) posited that Mechanical technology education is that segment of technical education which leads to the

acquisition of practical skills in motor vehicle, mechanic, machining, scaffolding, pipe fitting, welding, fabrication, foundry, forging, operation of equipment, and other industrial machines.
In mechanical technology, students are expected to work with materials, tools, equipment and machines for production activities that culminate in economic development of the nation. One of the key elements of mechanical technology education is its orientation towards the world of work, with the curriculum emphasizing the acquisition of employable skills. Udo as cited in Ajie *et al* (2024) state that the acquisition of the requisite skills is a means of increasing the productive power of nations, and that is one of the things that mechanical technology education is for.
Skills acquisition is one of the surest ways through which young people can find their ways into the labour market, either in the public or private sectors (Ehimen & Ezeora, 2018). In line with this submission, Akpan, (2013) referred to Sustainable employability skills as those skills that enable an individual to acquire and keep a job. It is necessary to note that skills are very important for economic development and job creation in every State. For any nation to survive, the provider of goods and services must be skilled at a rate that should improve the living standard of the people.
The modern education system has completely eradicated the space limitation of a classroom by encouraging the participation of more students from every corner of the world. By providing knowledge and skill through online platforms or websites, the modern education system has been able to attract a variety of students and teachers to participate in technology-based learning, freed from any kind of limitations of time, space or number of students. The popularity of online learning is increasing day by day. Online learning has paved way for the integration of Artificial Intelligene (AI), enabling personalized and adaptive educational experience.
AI, as part of online learning, has brought numerous changes in the educational sector. AI, according to Charara (2017) is a term used to describe a machine or computer programme that uses features of human-like thinking, such as planning, problem-solving or logical action, to undertake a task. Wartman and Combs (2018), see AI as the ability of a machine or computer to act or think like a human being, to imitate and accomplish things that people do. Similarly, Mohammed and Watson, as cited in Okoye and Mante (2024), described AI as the skillful manner of machines or technologies programmed to imitate humans. In recent decades, AI has become increasingly present in human lives, having a significant impact in various fields, including education.
Education has undergone a series of changes and under the impact of AI that brings with it the opportunity to transform and adapt the way teaching/learning processes are carried out. The major intention of AI in Education is to establish AI-powered systems such as virtual pedagogical agents. The implication of this is that AI robots and intelligent systems will allow for flexibility, ensuring smooth engaging of students and bringing about personalized learning, as well as to automate daily tasks of teaching, such as feedback and assessment. One of the key elements of AI is the ability to learn (Southgate *et al.,* 2018). This is achieved through the use of machine learning algorithms and artificial neural networks, which allow machines to process information, identify patterns and make predictions or decisions based on them.
AI in mechanical technology education programmes can be used to create tutorials and interactive virtual assistants, systems that can answer students' questions, provide additional explanations, and guide students in real-time through the learning process. Thus, through tutorials and virtual assistance, students can benefit from additional support and learn at an individualized pace, receiving real-time guidance to support the learning process (Mahendra, 2023).

Statement of the Problem

One of the technological advancements that AI has made considerable progress is becoming an essential component of the education sector. According to UNESCO (2021), fifty percent of worldwide organizations have incorporated AI into their day-to-day functions. Similarly, educational and training institutes teach their teachers and students the skills of AI. The learning and education sector have witnessed remarkable advancements in recent years due to technological innovations. Internet searches have become an integral part of school learning, and tablets have increasingly replaced or supplemented traditional books in universities. Lee & Hannafin (2016) explained that Students engagement is the key to academic success and well-being, involving active participation and investment in learning. Engaged students are motivated to achieve academic success, and remain in school. Classroom interactions fostering collaboration, critical thinking, and practical knowledge application enhance engagement. Educators utilizing creative teaching methods, technology, and student-centered approaches facilitate active learning and sustained engagement. Despite AI's potential, its utilization in mechanical technology education programmes remains uncertain. This study investigates AI's role in enhancing sustainable employability skills in tertiary institutions in Rivers State.

Purpose of the Study

This study examined utilization of AI in mechanical technology education programmes for sustainable employability skill development in tertiary institutions in Rivers State. Specifically, it investigated:

1. The extent of AI utilization in instruction delivery in mechanical technology education programmes for sustainable employability skills development in tertiary institutions in Rivers state.
2. The extent of AI utilization in workshop activities in mechanical technology education programme for sustainable employability skills development in tertiary institutions in Rivers state.

Research Questions

The following research questions were raised to guide the study:

1. To what extent is AI utilized in instruction delivery in mechanical technology education programmes for sustainable employability skills development in tertiary institutions in Rivers state?
2. To what extent is AI utilized in workshop activities in mechanical technology education programme for sustainable employability skills development in tertiary institutions in Rivers state?

Hypotheses

The following null hypotheses were tested at .05 level of significance:

1. There is no significant difference in the mean response of mechanical technology education lecturers and students on AI utilization in instructional delivery in mechanical technology education programmes for sustainable employability skills development in tertiary institutions in Rivers state.
2. There is no significant difference in the mean response of mechanical technology education lecturers and students on AI utilization in workshop activities in mechanical technology education programmes for sustainable employability skills development in tertiary institutions in Rivers state.

Methodology

The study was conducted in the two Rivers State-owned tertiary institutions (Universities) that offer mechanical technology education programmes. These tertiary institutions are Rivers State University, Port Harcourt, and Ignatius Ajuru University of Education, Rumuolomini,

Port Harcourt. The design of the study was a descriptive survey. The population for the study consisted of 108 year 1-IV mechanical technology education students and 36 lecturers. 48 third-year students were selected using cluster sampling technique, while the entire population of 36 lecturers was used for the study. The instrument for data collection was a structured questionnaire, face and content validated by two experts in the department of mechanical technology, Federal College of Education (Technical), Omoku, in affiliation with University of Nigeria, Nsukka, Enugu State. The instrument was structured in a four-point rating scale of Very High Extent (VHE), High Extent (HE), Low Extent (LE), and Very Low Extent (VLE). The reliability of the instrument was determined using Cronbach Alpha, after administering it to 7 lecturers and 12 Students, as respondents, at Federal College of Education (Technical), Omoku, in affiliation with University of Nigeria Nsukka, who were not part of the study. The reliability coefficient achieved was .84. The researchers administered the questionnaires to the respondents directly, and all were retrieved. Mean and Standard Deviation were used to answer research questions, while z-test statistical tool was used to test hypotheses. Mean value less than 2.50 was rejected, while mean value equal to or greater than 2.50 was accepted.

Results and Data Analysis

Research Question 1: To what extent is AI utilized in instruction delivery in mechanical technology education programmes for sustainable employability skills development in tertiary institutions in Rivers state?

Table 1: Means Responses on the Extent of AI Utilization in Instructional Delivery

		Lecturers =36			**Students =48**		
s/n	Items	$\bar{x}_1$	**SD_1**	Decision	$\bar{x}_2$	**SD_2**	Decision
1	The extent of AI utilization in Intelligent Tutoring Systems	2.00	.72	LE	1.51	.52	VLE
2	The extent of AI utilization in Adaptive Learning Platforms	2.22	.91	LE	1.44	.64	VLE
3	The extent of AI utilization in Virtual Reality in instructional delivery	1.63	.43	VLE	1.19	.62	VLE
4	The extent of AI utilization in shearing teaching/learning resources	1.93	.51	VLE	1.30	.71	VLE
5	The extent of AI utilization in intelligent assessment	2.02	.49	VLE	1.17	.83	VLE
6	The extent of AI utilization in analyzing students' data and performance trends.	2.12	.56	VLE	1.22	.76	VLE
7	The extent of AI utilization in tailoring teaching materials based on individual student requirements	1.89	.50	VLE	1.31	.50	VLE
8	The extent of AI utilization in Automated Grading Systems	1.60	.62	VLE	1.34	.62	VLE
9	The extent of AI utilization in understanding students' characteristics, forecast their learning outcomes, and identify at-risk students.	1.77	.71	VLE	1.29	.59	VLE
10	The extent of utilization of AI chatbots in providing students with instant answers to questions and support their learning.	1.73	.81	VLE	1.11	.88	VLE
11	The extent of utilization of Blubber in creating quizzes around YouTube videos	2.10	.52	VLE	1.14	.78	VLE
	Total	**1.74**	**.61**	**VLE**	**1.27**	**.67**	**VLE**

Source: Field Survey, 2025.

Table 1: On the extent to which AI is utilized in instructional delivery in mechanical technology education programmes for sustainable employability skills development in tertiary institutions in Rivers state, the table shows that lecturers and students agree that AI utilization is to a very low extent. This is based on grand mean scores of 1.74 and 1.27, respectively, which fall below the acceptable mean benchmark of 2.50. The standard deviations of .61 and .67, respectively, indicate homogeneity in their responses, suggesting a consensus between the two groups.

Research Question 2: To what extent is AI utilized in workshop activities in mechanical technology education programme for sustainable employability skills development in tertiary institutions in Rivers state?

Table 2: Mean Responses on the Extent of AI Utilization in Workshop Activities

		Lecturers =36			**Students =48**		
s/n	Items	$\bar{x}_1$	**SD_1**	Decision	$\bar{x}_2$	**SD_2**	Decision
1	The extent of AI utilization in milling machine operations	1.22	.51	VLE	1,00	.50	VLE
2	The extent of AI utilization in welding and fabrication processes	1.11	.44	VLE	1.34	.61	VLE
3	The extent of AI utilization in workpiece mounting process during lathe operation	1.40	.49	VLE	1.30	.88	VLE
4	The extent of AI utilization in demonstrating forging processes in the workshop	1.13	.61	VLE	1.32	.67	VLE
5	The extent of AI utilization in workpiece measuring processes in the workshop	1.29	.55	VLE	1.22	.71	VLE
6	The extent of AI utilization in displaying shearing processes in the workshop	1.23	.41	VLE	1.28	.51	VLE
7	The extent of AI utilization in illustrating foundry processes in the workshop	1.21	.60	VLE	1.41	.48	VLE
8	The extent of AI utilization in exhibiting casting processes in the workshop	1.51	.45	VLE	1.24	.54	VLE
	Total	**1.26**	**.50**	**VLE**	**1.26**	**.61**	**VLE**

Source: Field Survey, 2025.

Table 2: On the extent to which AI is utilized in workshop activities in mechanical technology education programmes for sustainable employability skills development in tertiary institutions in Rivers state, the table indicates that both lecturers and students agree that AI utilization is to a very low extent. This is based on grand mean scores of 1.26 and 1.26, respectively, which fall below the acceptable mean benchmark of 2.50. The standard deviations of .50 and .61, respectively, indicate homogeneity in their responses, suggesting a consensus between the two groups.

Hypothesis 1: There is no significant difference in the mean response of mechanical technology education lecturers and students on AI utilization in instructional delivery in mechanical technology education programmes for sustainable employability skills development in tertiary institutions in Rivers state.

Table 3: Summary of Results of Testing Null Hypothesis 1 Using Z-test Statistics

Category	**N**	$\bar{x}$	**SD**	**DF**	**z-cal**	**z-crit**	**Decision**
Lecturers	36	1.74	.61				
				82	3.35	1.98	Rejected
Students	48	1.27	.67				

The result in table 3 shows that the calculated-value (z-cal) is 3.35, while the critical z-value (z-crit) is 1.98 at .05 significance level. Since the calculated z-value (3.35) is greater than the critical z-value (1.98), the null hypothesis that there is no significant difference in the mean response of mechanical technology education lecturers and students on AI utilization in

instructional delivery in mechanical technology education programmes for sustainable employability skills development in tertiary institutions in Rivers state is rejected at .05 level of significance.

Hypothesis 2: There is no significant difference in the mean response of mechanical technology education lecturers and students on AI utilization in workshop activities in mechanical technology education programmes for sustainable employability skills development in tertiary institutions in Rivers state.

Table 4: Summary of Results of Testing Null Hypothesis 2 Using Z-test Statistics

Category	N	$\bar{x}$	SD	DF	z-cal	z-crit	Decision
Lecturers	36	1.26	.50				
				82	0.00	1.98	Accepted
Students	48	1.26	.61				

The result in table 3 shows that the calculated-value (z-cal) is .00, while the critical z-value (z-crit) is 1.98 at .05 significance level. Since the calculated z-value (.00) is less than the critical z-value (1.98), the null hypothesis that there is no significant difference in the mean response of mechanical technology education lecturers and students on AI utilization in workshop activities in mechanical technology education programmes for sustainable employability skills development in tertiary institutions in Rivers state is accepted at .05 level of significance.

Conclusion

The study examined the utilization of artificial intelligence in mechanical technology education programmes for sustainable employability skill development in tertiary institutions in Rivers State. Focusing on two key variables outlined in the study's purpose, the findings revealed that AI utilization in mechanical technology education programmes is very low. despite Artificial Intelligence emerging as a transformative force across various sectors, offering innovative solutions to complex problems, its adoption in Mechanical technology education remains limited. In educational realm, AI has the potential to revolutionize traditional teaching methods and streamline research processes. Given Nigeria's need to keep pace with global digital advancements, mechanical technology education lecturers must acquire the necessary digital skills to enhance instructional delivery and practical skills imparting in these programmes.

Recommendations

Based on the findings of this study, the following recommendations were made:

1. Lecturers should be trained on developing and applying Artificial Intelligence packages in instructional delivery and workshop activities in mechanical technology education programmes in tertiary institutions in Rivers State.
2. Management of Institutions of higher learning should provide facilities such as reliable internet services to support the use of artificial intelligence.
3. Resource persons should be engaged to teach mechanical technology education students how to utilize various artificial intelligence tools for a robust academic and skill development purposes.

References

Abel, B. I. (2021). The Strategies for Improving Skill Acquisition of Building Technology Students in Colleges of Education in Nigeria. *International Journal of Education and Research, 4*(7), 20-31.

Ajie, P. M.; Ojobah, L.O., & Onyeaju, A. I. (2024). Perceived Factors Affecting Practical Skill Acquisition amongst Mechanical Technology Education Undergraduates in Tertiary Institutions in Rivers State. *African Journal of Advances in Sciences and Technology Research, 15*(1), 46-58.

Charara, S. (2017). Over two million school kids have gone on Google Expeditions. Wearable. Retrieved March 24, 2025, https://www.wareable.com/google/expeditions-two-million-cardboard-666.

Ehimen, T. E., & Ezeora, B. U. (2018). Metalwork Practice Skills Needed by Technical College Graduates for Sustainable Employment in Edo and Enugu States of Nigeria. *International Journal of Education and Evaluation, 4*(6), 62-69.

Mahendra, S. (2023). "How is AI Being Used in Education." Available at https://www.aiplusinfo.com/blog/how-is-ai-being-used-in-education/, accessed on May 23, 2023.

Okoye, M. C., & Mante, A. D. (2024). The Nexus Between Artificial Intelligence and STEM Education Transformation in Nigeria. *International Journal of Research and Innovation in Social science, 8*(3s), 3793-3809.

Southgate, E., Blackmore, K., Pieschl, S., Grimes, S., McGuire, J., & Smithers, K. (2018). Artificial intelligence and emerging technologies (virtual, augmented and mixed reality) in schools: A research report. Newcastle: University of Newcastle, Australia.

UNESCO (2021). Understanding the impact of artificial intelligence on skills development. UNESCO- UNEVOC International Centre for Technical and Vocational Education and Training. Available at: http://creativecommons.org/licenses/bysa/3.0/igo/.

Wartman, S. A., & Combs, C. D. (2018). Medical education must move from the information age to the age of Artificial Intelligence. *Academic Medicine*, *93*(8), 1107-1109.

CHALLENGES IN ADOPTING ARTIFICIAL INTELLIGENCE FOR 21st CENTURY SKILL ACQUISISTION OF MECHANICAL TECHNOLOGY EDUCATION STUDENTS' IN TERTIARY INSTITUTIONS IN RIVERS STATE

[1]AJIE, Prince Maduabuchukwu (Ph.D), [2]OTOBOH, Christian Obi; [3]ELUOZO, Progress Ozioma, & [4]OGBANGA, Ibifuro

[1,3,&4]Department of Metalwork Technology Education, Federal College of Education (Technical) Omoku, Rivers State, Nigeria.

ajiemiprince@gmail.com. 07086099931

ORCID iD; https://orcid.org/0009-0009-1540-6924

[2]Department of Automobile Technology Education, Federal College of Education (Technical) Omoku, Rivers State.

christobi2015@gmail.com, 08066653236

ABSTRACT

This study investigated the challenges in adopting artificial intelligence for 21st Century Skill Acquisition of mechanical technology education students' in tertiary institutions in Rivers State. Two research purposes and questions were raised, while two hypotheses were tested at 0.05 level of significance. A descriptive survey design guided the study. The population of the study was 68 teaching staff and 41 non-teaching staff in mechanical technology education from the three tertiary institutions in Rivers State that offers the programmes, the entire population was sampled. The researchers collected data for the study using questionnaires. The instrument was validated by two lecturers. The reliability coefficient achieved using Cronbach Alpha Reliability Coefficient was .84. Mean was used to answer the research questions while standard deviation was used to determine the homogeneity in the responses, z-test was used to test the hypothesis at 0.5 level. The study found among others that most mechanical technology education lecturers and non-lecturers lacks the digital skills to utilize AI platforms to suit student's skill acquisition in the 21st century, it was recommended that mechanical lecturers should be trained to enable them obtain the digital skill in ICT applications, creativity, and skills in designing /utilizing AI packages for effective mechanical technology students skill acquisition in the 21st century in tertiary institutions in Rivers State.

Keywords: Artificial Intelligence. Mechanical technology education, Skill Acquisition, 21st Century

Introduction

Education plays a key role in the development of human skill and civilization. Since ancient times, the method of learning is constantly evolving and undergoing numerous changes due to new technologies. We are all familiar with traditional ways of learning where education is imparted within the walls of classrooms to a group of students. With the intervention of the internet and digital technology, the online platform is trending slowly and surely taking the place of classrooms (Muresan, 2023). Thus, the modern education system has completely eradicated the space limitation of a classroom by encouraging the participation of more students from every corner of the world. By providing knowledge and skill through online platforms or websites, the modern education system has been able to attract a variety of students and teachers to participate in technology-based learning. Freed from any kind of limitations of time, space or number of students, the popularity of online learning is increasing day by day.

Artificial intelligence (AI) as part of online learning has brought numerous changes in the educational sector. Artificial Intelligence (AI) according to Charara (2017) is a term used to describe a machine or computer program that uses features of human-like thinking, such as

planning, problem-solving or logical action, to undertake a task. In their view, Wartman and Combs (2018), sees AI as the ability of a machine or computer to act or think like a human being, to imitate and accomplish things that people do. Similarly, Mohammed and Watson cited in Okoye and Mante (2024) described AI as the skillful manner of machines or technologies programmed to imitate humans. In recent decades, AI has become increasingly present in our lives, having a significant impact in various fields, including education. Education has undergone a series of changes and under the impact of AI that brings with it the opportunity to transform, to adapt the way the teaching/learning process is carried out. The major intention of Artificial Intelligent in Education is to establish AI-powered systems such as virtual pedagogical agents, meaning, AI robots and intelligent systems will allow for flexibility, ensuring smooth engaging of students and bringing about personalized learning as well as to automate daily tasks of teaching for example feedback and assessment. Southgate *et al* (2018) states that one of the key elements of AI is the ability to learn. This is achieved through the use of machine learning algorithms and artificial neural networks, which allow machines to process information, identify patterns and make predictions or decisions based on them.

Okparaeke in Abel (2021), states that Mechanical technology education is one of the vocational and technical education programmes offered in higher institutions designed to produce mechanical technicians for production industry and for self-reliance. Mechanical technology education is an education for practical skills. It is a part of technical education which the expected end is to produce skilled personnel for employment, being self-reliant, and contribute meaningfully to national development. Similarly, Ajie, Ojobah, & Onyeaju, (2024) described it is that segment of technical education which leads to the acquisition of practical skills in motor vehicle, mechanic, machining, scaffolding, pipe fitting, welding, fabrication, foundry, forging, operation of equipment, appliances and other industrial machines. In mechanical technology, students are expected to work with materials, tools, equipment and machines for production activities for economic development of the nation.

One of the key elements of mechanical technology education as viewed by many and the government in the past years, is its orientation towards the world of work with the curriculum emphasizing the acquisition of employable skills. Udo as cited in Ajie *et al* (2024) state that the acquisition of the requisite skills is a means of increasing the productive power of nations, and that is one of the things that mechanical technology education is for.

Skill acquisition is knowledge and training in the area of using intellectual thinking and skillful manipulation of instruments and equipment to produce functional designs and products, and such training acquired by skilled workers is a job that cannot be perfumed by anybody, (Dashen in Bulus, 2015). In line with this (Ubong and Oguzor in Kumazhege and Egunsola, 2017) opine that practical skill acquisition is best defined by the learner as the process of obtaining knowledge of technical and practical nature from an individual, group, or institution that can impart such knowledge.

AI is revolutionizing the field of education, particularly in higher education, by providing significant advancements in teaching, learning, and administrative processes. One of the primary reasons AI is important in education is its ability to offer personalized learning experiences. AI systems can analyze vast amounts of data to tailor educational content to meet the unique needs of each student, enhancing their learning outcomes (Akinwalere & Ivanov, 2022).

AI in mechanical technology education can be used to create tutorials and interactive virtual assistants, systems that can answer students' questions, provide additional explanations, and guide students in real-time through the learning process. Thus, through tutorials and virtual assistance students can benefit from additional support and learn at an individualized pace receiving real-time guidance to support the learning process (Mahendra 2023).

Statement of the Problem

In education sector, currently, Artificial Intelligent (AI) is finding relevance as one of the emerging technologies which bring about effectiveness in teaching-learning process. This owns to the fact that, AI is refers to as science and as well engineering of making an intelligent machine for human used and it possess the ability to think, reach, and which surpass ordinary human-level of intelligence in the 21st century. This therefore means the fast development of technology and social media have both brought about substantial changes to the ways in which humans communicate with each other and the effectiveness of social networks (Rabiatu, & Shehu, 2024.). It has been established that, AI has been extensively used in education in different forms such as computer programs, humanoid robots, web-based chat-bots, and online platforms. Surprisingly the adoption of AI in mechanical technology is yet to fully, as Rabiatu, & Shehu (2024) opine that the challenges in adopting AI in mechanical education skill acquisition among others include; Lack of adequate infrastructure, such as reliable internet connectivity, electricity, and devices, that are essential for the delivery and use of AI-based educational solutions. Inadequate of needed skills and awareness, among both learners and educators, on how to effectively use and evaluate AI-based educational solutions, as well as how to protect their privacy and security in the digital environment. It is based on these that the researchers deemed it necessary to carry out this investigation

Purpose of Study

The study is focused on investigating the challenges in adopting artificial intelligence for 21st Century Skill Acquisition of mechanical technology education students' in tertiary institutions in Rivers State. Specifically, the study investigated;

1. The instructional delivery challenges in adopting AI for 21st century skill acquisition of mechanical technology education students in tertiary institution in Rivers State.
2. The administration challenges in adopting AI for 21st century skill acquisition of mechanical technology education students in tertiary institutions in Rivers State

Research Question

The following research questions guided the study

1. What are the instructional delivery challenges in adopting AI for 21st century skill acquisition of mechanical technology education students in tertiary institution in Rivers State?
2. What are the administration challenges in adopting AI for 21st century skill acquisition of mechanical technology education students in tertiary institutions in Rivers State?

Hypothesis

The following null hypotheses were tested at .05 level of significance:

1. There is no significant difference in the mean response of mechanical technology education teaching and non-teaching staff on the instructional delivery challenges in adopting AI for 21st century skill acquisition of mechanical technology education students in tertiary institution in Rivers State.
3. There is no significant difference in the mean response of mechanical technology education teaching and non-teaching staff on the administration challenges in adopting AI for 21st century skill acquisition of mechanical technology education students in tertiary institutions in Rivers State.

Methodology

The study was carried out in the three tertiary institutions that offer mechanical technology education programmes. These tertiary institutions are Rivers State University Port Harcourt, Ignatius Ajuru University of Education, Rumuolomini, Port Harcourt, and Federal College of Education (Technical) Omoku River State in affiliation with University of Nigeria Nsukka. The design of the study was a descriptive survey. The population of the study comprised of 68

and 41 mechanical technology education lecturers and workshop technologists respectively in these tertiary institutions. The entire population was sampled for the study using purposive sampling technique. The instrument for data collection was face and content validated by three experts in the department of mechanical technology in Niger Delta University, Bayelsa State The instrument was structured in a four-point rating scale of strongly agree (SA), agree (A), disagree (D), and strongly disagree (SD). The reliability of the instrument was determined using Cronbach Alpha Reliability method, test after administering it to 7 and 4 lecturers and non-lecturers as respondents in Niger Delta University, who were not part of the study, the reliability coefficient achieved was 0.84. The researchers administered the questionnaires to the respondents directly and all the instrument were retrieved. Mean and Standard Deviation were used to answer the research questions while z-test statistical tool was used to test the hypotheses of the instrument. Mean value 2.50 was set as cut off point for mean less than 2.50 was rejected while mean value equal or greater than 2.50 was accepted.

Results and Discussions

Research Question 1; What are the instructional delivery challenges in adopting AI for 21st century skill acquisition of mechanical technology education students in tertiary institution in Rivers State?

Table 1, means responses on the instructional delivery challenges in adopting AI in mechanical Technology education

s/n	Items	Lecturers= 68			Technologist = 41		
		$\bar{x}_1$	SD_1	Decision	$\bar{x}_2$	SD_1	Decision
1	Difficulties in using AI in an enable classroom to address the digital divide and avoid exacerbating existing inequalities that already in existence	3.29	.84	Accept	3.00	.91	Accept
2	Lack of adequate infrastructure, such as reliable internet connectivity, electricity, and devices, that are essential for the delivery and use of AI-based educational solutions.	3.82	.91	Accept	3.83	.85	Accept
3	Lack of relevant data and content, such as local languages, curricula, and cultural contexts, that are needed to train and customize AI models for the specific learning needs	3.44	.89	Accept	3.22	.87	Accept
4	Inadequate of needed skills and awareness, among both learners and educators, on how to effectively use and evaluate AI-based educational solutions, as well as how to protect their privacy and security in the digital environment.	3.22	.92	Accept	3.83	1.00	Accept
5	Absence of regulatory frameworks, that can support the development, deployment, and governance of AI in education.	3.82	.79	Accept	3,99	.93	Accept
	TOTAL	**3.51**	**.87**	**Accept**	**3.57**	**.91**	**Accept**

Sources. Field Survey 2025

Table 1: On the instructional delivery challenges in adopting AI for 21st century skill acquisition of mechanical technology education students in tertiary institution in Rivers State, shows that lecturers and technologist agreed that all the items posted above are the instructional delivery challenges in adopting AI for 21st century skill acquisition of

mechanical technology education students in tertiary institution in Rivers State. This is based on the grand mean score of 3.51 and 3.57 respectively which is above 2.50 that was earlier stated as the acceptable means. Furthermore, the closeness in the standard deviation for the two groups which is .87 and .91 shows homogeneity in their responses.

Research Question 2: What are the administrative challenges in adopting AI for 21st century skill acquisition of mechanical technology education students in tertiary institutions in Rivers State?

Table 2, means responses on the administration challenges in adopting AI in mechanical Technology education

s/n	Items	Lecturers= 68			Technologist = 41		
		$\bar{x}_1$	SD_1	Decision	$\bar{x}_2$	SD_1	Decision
1	Violation of privacy and the uncertainty brought by AI	3.29	.92	Accept	3.10	.98	Accept
2	Negative effects of ridesharing technology adoption	3.82	.79	Accept	3.93	.91	Accept
3	Lack of managerial skill to handle AI in school administration for data organization, control, and storage,	3.44	1.11	Accept	3.27	.78	Accept
4	lack of Resources for the Development of AI Packages and Advanced Technologies for school Services	3.22	.91	Accept	3.83	1.21	Accept
5	difficulties in comprehending how artificial intelligence (AI) creates value and successfully integrating it into administrative operations	3.82	.85	Accept	3,99	1.10	Accept
6	Deplorable State of ICT Training Laboratry	4.21	.89	Accept	3.90	.90	Accept
	TOTAL	**3.63**	**.91.**	**Accept**	**3.66**	**.98**	**Accept**

Source: Field Survey 2025

Table 1: On the administration challenges in adopting AI for 21st century skill acquisition of mechanical technology education students in tertiary institutions in Rivers State, shows that lecturers and technologist agreed that the items posted above among others are the administration challenges in adopting AI for 21st century skill acquisition of mechanical technology education students in tertiary institution in Rivers State. This is based on the grand mean score of 3.63 and 3.66 respectively which is above 2.50 that was earlier stated as the acceptable means. Furthermore, the closeness in the standard deviation for the two groups which is .91 and .98 shows homogeneity in their responses.

Hypothesis 1

There is no significant difference between the mean response of mechanical technology education teaching and non-teaching staff on the instructional delivery challenges in adopting AI for 21st century skill acquisition of mechanical technology education students in tertiary institution in Rivers State.

Table 3; t-Test Analysis on the instructional delivery challenges in adopting AI for 21st century skill acquisition of mechanical technology education students

Category	N	$\bar{x}$	SD	DF	t-cal	t-crit	Remark
Teaching Staff	68	3.51	.87				
				107	0.34	1.96	Accepted
Non-Teaching Staff	41	3.57	.91				

Table 3 shows that teaching staff mean and standard deviation scores were 3.51 and .87 respectively, while non-teaching staff mean and standard deviation scores were 3.57 and .91

respectively. The t-cal value was 0.34 while the t-crit was 1.96 with DF = 107 at .05 level of significance. This result shows that t-cal was less than t-crit, which means that the null hypothesis was accepted. Thus, there was no significant difference in the mean response of mechanical technology education teaching staff and non-teaching staff on the instructional delivery challenges in adopting AI for 21st century skill acquisition of mechanical technology education students in tertiary institution in Rivers State.

Hypothesis 2.

There is no significant difference between the mean response of mechanical technology education teaching and non-teaching staff on the administration challenges in adopting AI for 21st century skill acquisition of mechanical technology education students in tertiary institutions in Rivers State.

Table 4; t-Test Analysis on the Administration challenges in adopting AI for 21st century skill acquisition of mechanical technology education students

Category	N	$\bar{x}$	SD	DF	t-cal	t-crit	Remark
Teaching Staff	68	3.63	.91				
				107	0.16	1.96	Accepted
Non-Teaching Staff	41	3.66	.98				

Table 4 shows that teaching staff mean and standard deviation scores were 3.63 and .91 respectively, while non-teaching staff mean and standard deviation scores were 3.66 and .98 respectively. The t-cal value was 0.16, while the t-crit was 1.96 with DF = 107 at .05 level of significance. This result shows that t-cal was less than t-crit, which means that the null hypothesis was accepted. Thus, there was no significant difference in the mean response of mechanical technology education teaching and non-teaching staff on the administration challenges in adopting AI for 21st century skill acquisition of mechanical technology education students in tertiary institution in Rivers State.

Conclusion

Result from the findings has shown the challenges in adopting AI for 21st century skill acquisition of mechanical technology education students in tertiary institutions in Rivers State. in conclusion, the value of education in human lives cannot be overstated in today's modern education because it enhances both human and material resources. According to Karmanje and Alhassan (2018), education was obtained one-on-one in the human history of civilization, using face-to-face direct teaching and learning techniques. However, today's technology is increasingly used in teaching and learning (Kataria, 2018). One technological advancement, artificial Intelligence (AI), has made considerable progress in becoming an essential component of the education sector. More so, UNESCO (2021), states that fifty percent of worldwide organizations have incorporated artificial Intelligence into their day-to-day functions. Similarly, educational and training institutes teach their teachers and students the skills of artificial intelligence because it improves critical thinking, creative skills, and analytic skills, among other things.

Recommendation

Arising from the results of this study, the researchers propose the following recommendations presented under four thematic topics

1. **Teacher Training and Development:** The government should prioritize the recruitment of AI experts to train educators, empowering them to harness AI in their teaching practices. Transforming teachers into tech-savvy facilitators will maximize AI's potential to create engaging, individualized learning experiences, enhancing 21st century skill acquisition of mechanical technology education students in tertiary institutions in Rivers State.

2. **Policy Integration:** Educational policymakers should mandate the strategic incorporation of AI technologies into mechanical technology educational frameworks. This initiative will revolutionize teaching and learning by fostering a more dynamic, adaptive, and personalized educational environment aligned with the 21st century learning processs

Reference

Abel, B. I. (2021). The Strategies for Improving Skill Acquisition of Building Technology Students in Colleges of Education in Nigeria. *International Journal of Education and Research* 4(7) 20-31

Ajie, P. M.; Ojobah, L.O. and Onyeaju, A. I, (2024) Perceived Factors Affecting Practical Skill Acquisition amongst Mechanical Technology Education Undergraduates in Tertiary Institutions in Rivers State. *African Journal of Advances in Sciences and Technology Research* 15(1) 46-58.

Akinwalere, S. N., & Ivanov, V. (2022). Artificial Intelligence in Higher Education: Challenges and Opportunities. Border Crossing, 12(1), 1 - 15.

Bulus, G. B. (2015) Skill acquisition and vocational education in non-formal education: its implication for National Development. *Journal of Resourcefulness and Distinction,* 11(1)1-9.

Charara, S. (2017). Over two million school kids have gone on Google Expeditions. Wearable. Retrieved March 24 2025, https://www.wareable.com/google/expeditions-two-million-cardboard-666.

Karmanje, A. R. &Alhassan, N. S. (2018). Impact of technology on teaching and learning. *International Journal of Research and Analytical* 2(4) 39-43

Kataria, M. V. (2018). Challenges in effective implementation of e-learning platforms in apparel education. *International Journal of Research and Analytical Reviews*, 5(2) 1 – 14.

Kumazhege, S.Z, and Egunsola, A. O. E. (2017), Technical Teachers' Perception of Factors Affecting Practical Skill Acquisition among Technical College Graduates in Adamawa State Nigeria, *Educational Research International*. 3(3) 96-101

Muresan, M. (2023) Impact of Artificial Intelligence on Education. *Research Association for Interdisciplinary Studies Conference Proceedings*, 2023, 82-85.

Mahendra, Sanksshep. (2023.) „How is AI Being Used in Education." Available at https://www.aiplusinfo.com/blog/how-is-ai-being-used-in-education/, accessed on May 23, 2023.

Okoye, M. C. and Mante, A. D. (2024) The Nexus Between Artificial Intelligence and STEM Education Transformation in Nigeria. *International Journal of Research and Innovation in Social science* VIII (IIIS).3793-3809

Rabiatu, M. M. and Shehu, S. A. (2024). Adopting Artificial Intelligence (AI) in Education: Challenges & Possibilities. *Asian Journal of Advanced Research and Report,* 18(2) 106-111.

Southgate, E., Blackmore, K., Pieschl, S., Grimes, S., McGuire, J. & Smithers, K. (2018). Artificial intelligence and emerging technologies (virtual, augmented and mixed reality) in schools: A research report. Newcastle: University of Newcastle, Australia.

UNESCO (2021). Understanding the impact of artificial intelligence on skills development. UNESCOUNEVOC International Centre for Technical and Vocational Education and Training. Available at: http://creativecommons.org/licenses/bysa/3.0/igo/

Wartman, S. A., & Combs, C. D. (2018). Medical education must move from the information age to the age of Artificial Intelligence. *Academic Medicine*, 93(8), 1107-1109.

TEACHERS' READINESS TO UTILIZE ARTIFICIAL INTELLIGENCE IN IMPLEMENTATING MOTOR VEHICLE MECHANIC'S WORK CURRICULUM IN FEDERAL CAPITAL TERRITORY, ABUJA, NIGERIA

[1]JUTUM Joel Isiah; [2]ARAH Abubakar Saidu PhD & [3]BINNI Danjuma Beji, PhD

[1]Department of Educational Foundation, Facuulty of Education,
Taraba State University, Jalingo, Nigeria

[2]Department of Motor Vehicle Mechanics Work,
Vocational Enterprises Institute, Karshi, Abuja, Nigeria

[3]Department of Building Technology Education,
Niger State College of Education, Minna, Nigeria

Email: joeljutum@outlook.com
Phone: +2347032916777

Abstract

This study investigated the current level of teachers' readiness to utilize Artificial Intelligence (AI) in implementing the Motor Vehicle Mechanics Work (MVMW) curriculum and identified strategies for enhancing this readiness in technical colleges and vocational institutes in the Federal Capital Territory (FCT), Abuja, Nigeria. Two research questions guided the study. Additionally, two null hypotheses regarding differences in responses among teachers, administrators, and ICT support staff were tested at the 0.05 significance level. A descriptive survey design with a cross-sectional approach was adopted, involving the entire population of 31 respondents (12 MVMW teachers, 9 administrators, and 10 ICT support staff). Due to the manageable size of the population, there was no sampling. Data were collected using a validated 12-item Likert-scale questionnaire, yielding a reliability coefficient of 0.87. Analysis through descriptive statistics and ANOVA revealed that teachers currently lack adequate readiness to utilize AI in MVMW instruction, with no significant differences in perceptions across respondent groups. Strategies identified to enhance readiness included regular AI workshops, provision of infrastructure, integration of AI modules in teacher education, incentives, continuous ICT support, and inclusion of AI goals in performance evaluations, again with no significant differences among groups. Based on the findings, the study recommended that the Federal Ministry of Education and the National Board for Technical Education (NBTE) should initiate targeted capacity-building programs for teachers that provide hands-on training in AI tools relevant to MVMW instruction.

Keywords: Artificial Intelligence, Teacher Readiness and Motor Vehicle Mechanics Work curriculum

Introduction

Technical and vocational education plays a vital role in preparing learners for employment and self-reliance through skill-based training such as motor vehicle mechanic's work. The Motor Vehicle Mechanic's Work (MVMW) curriculum is designed to develop competencies in diagnostics, servicing, repairs, and routine maintenance of automobiles. Its objectives include enabling students to use automotive tools, interpret vehicle systems, troubleshoot faults, and carry out both preventive and corrective repairs (National Board for Technical Education [NBTE], 2013; Okolie *et al.,* 2021). Despite the curriculum's robust design, technical institutions in Nigeria, particularly those within the Federal Capital Territory (FCT), Abuja face multiple implementation challenges. These include limited infrastructure, outdated equipment, inadequate learning materials, and insufficient integration of modern industry

practices. Addressing these challenges and modernizing instructional delivery now requires exploring innovative solutions such as artificial intelligence.

Artificial Intelligence (AI) refers to computer systems capable of performing tasks that typically require human intelligence, such as learning, reasoning, and adapting. In education, AI has shown immense potential in enhancing instruction through tools like intelligent tutoring systems, virtual simulations, and automated assessments (Russell & Norvig, 2016; UNESCO, 2022). Within the MVMW context, AI technologies can simulate real-world automotive diagnostics, provide interactive learning experiences, and help bridge the gap between outdated teaching methods and modern workshop practices. These tools offer significant benefits by compensating for the lack of physical equipment and supporting instructors in delivering more effective training. However, the extent to which these technologies can transform MVMW education depends heavily on teachers' readiness.

Teachers' readiness refers to the degree to which educators are prepared with the knowledge, technical proficiency, and pedagogical skills necessary to integrate emerging technologies into instruction. In technical and vocational settings where hands-on training is essential, teachers must go beyond content delivery to actively facilitate learning through digital simulations and interactive platforms (Ghavifekr & Rosdy, 2015; Alhassan & Bello, 2023). A teacher who is adequately ready can utilize AI tools to enhance student engagement, reinforce practical competencies, and align instruction with industry expectations. Conversely, a lack of readiness can result in ineffective implementation, missed learning opportunities, and continued reliance on obsolete teaching practices. Therefore, building teacher capacity is essential to the successful implementation of AI-supported MVMW instruction.

The consequences of inadequate teacher readiness to use AI in delivering the MVMW curriculum are far-reaching. Without this readiness, institutions risk graduating students who are ill-equipped for the evolving demands of the automotive industry, thus exacerbating the skills gap and undermining national development goals. Persisting with outdated teaching approaches will also limit curriculum impact and student performance. These realities underscore the need to assess teachers' readiness to adopt AI tools in MVMW instruction within the FCT, Abuja. Understanding this readiness will help identify critical capacity gaps, guide policy reforms, and improve the quality and relevance of vocational education in Nigeria.

Statement of the Research Problem

Ideally, the implementation of the Motor Vehicle Mechanic's Work (MVMW) curriculum in technical and vocational education should equip learners with industry-relevant competencies in diagnostics, servicing, repairs, and maintenance using up-to-date methods and technologies. Such a curriculum is intended to foster employability and align technical training with the demands of modern automotive industries. However, in practice, especially in technical institutions within the Federal Capital Territory (FCT), Abuja, a significant gap exists between the intended goals of the MVMW curriculum and its actual classroom implementation. Instruction is still largely characterized by outdated teaching methods, minimal exposure to modern automotive technologies, and a lack of Artificial Intelligence (AI)-enabled instructional tools. These gaps continue to hinder the delivery of hands-on, industry-relevant training, as observed by Agbo and Ogbuanya (2021) and supported by the findings of Bello and Garba (2023). The root of this challenge lies primarily in the low level of teacher readiness to adopt and integrate AI tools effectively into pedagogical practice.

Although scholars and policymakers, such as Umar and Danladi (2022), along with Oladiran and Ajayi (2023), have made commendable efforts to promote the integration of emerging technologies into Nigerian technical education, teachers' preparedness to use such

technologies remains a persistent and unresolved issue. This issue has persisted for over a decade, despite increasing advocacy for digital transformation in education. The continued low level of teacher readiness poses significant consequences: it results in the production of graduates who are unprepared for the digitalized automotive industry, widens the skills gap in the labour market, and undermines national goals aimed at promoting industrialization, employment, and youth empowerment. According to the International Labour Organization (2023) and further emphasized by Okonkwo and Ibrahim (2024), this growing disconnect between training outcomes and labour market expectations demands urgent attention. Given the growing relevance of AI in both automotive technology and educational delivery, this study sought to assess the current level of teachers' readiness and to identify strategic approaches to enhance their capacity for AI-based instruction.

Aim and Objectives of the Study

The aim of the study was to determine teachers' readiness to utilize Artificial Intelligence (AI) in implementing the Motor Vehicle Mechanics Work (MVMW) curriculum in the Federal Capital Territory (FCT), Abuja, Nigeria. The objectives of the study were to:

7. Assess the current level of teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja, Nigeria.
8. Determine strategies for enhancing teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja, Nigeria.

Research Questions

The following research questions were raised and answered:

23. What is the current level of teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja, Nigeria?
24. What are the strategies for enhancing teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja, Nigeria?

Hypotheses

The following null hypotheses were formulated and tested at the 0.05 level of significance:

HO_1: There is no significant difference among the mean responses of teachers, administrators, and ICT support staff on the current level of teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja, Nigeria.

HO_2: There is no significant difference among the mean responses of teachers, administrators, and ICT support staff on strategies for enhancing teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja, Nigeria.

Methodology

This study adopted a descriptive survey research design with a cross-sectional approach. The design was considered appropriate because it facilitates the collection and analysis of data from a defined population at a specific point in time (Creswell, 2023). The area of the study was the Federal Capital Territory (FCT), Abuja, Nigeria. The population for the study comprised all the 12 MVMW teachers, 9 administrators, and 10 ICT support staff, giving a total of 31 respondents. Since the population was small and manageable, the entire population was studied without employing any sampling technique.

Data for the study were collected using a structured Likert-scale questionnaire comprising 12 items aligned with the two research questions. The response options were: Strongly Agree (5 points), Agree (4 points), Disagree (3 points), Strongly Disagree (2 points), and Undecided (1 point). The first six items assessed the current level of teachers' readiness to utilize AI in implementing the MVMW curriculum, while the remaining six focused on strategies for

enhancing such readiness. The instrument was subjected to face and content validation by three experts, one each from the fields of educational technology, technical and vocational education, and ICT who reviewed the questionnaire for clarity, relevance, and alignment with the research objectives.

To ensure the reliability of the instrument, a pilot test was conducted, and the Cronbach's Alpha method was used to estimate the internal consistency of the items. The overall reliability coefficient obtained was 0.87, indicating that the questionnaire had a high level of internal consistency and was suitable for the study (Tavakol & Dennick, 2021). Questionnaires were administered in both physical and electronic formats with the support of research aides familiar with the institutions involved. All 31 questionnaires were successfully retrieved, yielding a 100% response rate. Data collected were analyzed using descriptive statistics (mean and standard deviation) to answer the research questions and Analysis of Variance (ANOVA) to test the null hypotheses.

Results:

Research Question 1

What is the current level of teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja, Nigeria? Results for answering research question one are displayed in Table 1.

Table 1: Mean and standard deviation of the respondents' responses on the current level of teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja, Nigeria

S/N	Items	Mean	SD	Remark
1	Teachers in my institution are familiar with the basic concepts of Artificial Intelligence (AI) relevant to the MVMW curriculum.	2.56	1.26	Disagreed
2	Teachers have received adequate training on how to use AI tools for teaching MVMW.	1.58	1.23	Strongly Disagreed
3	Most MVMW teachers can effectively apply AI-powered tools (e.g., chatbots, simulations, analytics) in instruction.	2.42	1.21	Disagreed
4	The institution provides adequate infrastructure to support the integration of AI in MVMW teaching.	1.56	1.09	Strongly Disagreed
5	Teachers demonstrate confidence in integrating AI into MVMW lesson planning and delivery.	1.62	1.31	Strongly Disagreed
6	Teachers are willing to adopt AI technologies to improve teaching and learning in the MVMW curriculum.	3.56	1.03	Agreed
	Grand Mean	**2.22**	**1.19**	**Strongly Disagreed**

Table 1 shows the mean and standard deviation for respondents' views on the current level of teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja. The grand mean of 2.22 with a standard deviation of 1.19 indicates that respondents strongly disagreed that teachers are currently ready to integrate AI in implementing MVMW curriculum, reflecting a generally low level of readiness.

Research Question 2

What are the strategies for enhancing teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja, Nigeria? Results for answering research question two are displayed in Table 2.

Table 2: Mean and standard deviation of the respondents' responses on the strategies for enhancing teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja, Nigeria

S/N	Items	Mean	SD	Remark
1	Organizing regular AI-focused workshops and training for teachers will enhance readiness.	3.94	.98	Agreed
2	Providing AI infrastructure and digital tools will encourage teachers to adopt AI in teaching.	3.96	1.01	Agreed
3	Incorporating AI modules in teacher education programs will build competence and readiness.	3.80	1.05	Agreed
4	Offering incentives or recognition to teachers who integrate AI can increase adoption and readiness.	3.87	.96	Agreed
5	Continuous technical support from ICT staff will improve teachers' confidence in using AI.	3.78	.97	Agreed
6	Including AI utilization goals in performance evaluations can enhance teachers' commitment to readiness.	3.91	1.03	Agreed
	Grand Mean	**3.88**	**.83**	**Agreed**

Table 2 presents the mean and standard deviation for respondents' views on strategies for enhancing teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja. The grand mean of 3.88 with a standard deviation of 0.83 indicates that respondents agreed that the identified strategies are effective in improving teachers' readiness to adopt AI in implementing MVMW curriculum.

Hypothesis One

There is no significant difference among the mean responses of teachers, administrators, and ICT support staff on the current level of teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja, Nigeria. Results for testing hypothesis one is presented in Table 3.

Table 3: Analysis of Variance showing the significant difference among the mean responses of teachers, administrators, and ICT support staff on the current level of teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja, Nigeria.

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.481	2	.481	13.012	.081*
Within Groups	.961	28	.037		
Total	1.442	30			

Table 3 shows the analysis of variance with a between-group mean square of 0.481, a within-group mean square of 0.037, an F-value of 13.012, and a p-value of 0.081. These values indicate that there is no statistically significant difference among the mean responses of teachers, administrators, and ICT support staff on the current level of teachers' readiness to utilize AI in implementing the MVMW curriculum, as the p-value (.081) is greater than 0.05.

Hypothesis Two

There is no significant difference among the mean responses of teachers, administrators, and ICT support staff on strategies for enhancing teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja, Nigeria. Results for testing hypothesis one is presented in Table 4.

Table 4: Analysis of Variance showing the significant difference among the mean responses of teachers, administrators, and ICT support staff on strategies for enhancing teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja, Nigeria.

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.741	2	4.741	87.981	.099*

Within Groups	8.192	28	.054
Total	12.933	30	

Table 4 shows the analysis of variance with a between-group mean square of 4.741, a within-group mean square of 0.054, an F-value of 87.981, and a p-value of 0.099. These values indicate that there is no statistically significant difference among the mean responses of teachers, administrators, and ICT support staff on strategies for enhancing teachers' readiness to utilize AI in implementing the MVMW curriculum, as the p-value (.099) is greater than 0.05.

Findings

5. Teachers were found to lack adequate readiness to utilize AI in implementing the MVMW curriculum in FCT Abuja, Nigeria.
6. There was no significant difference among the mean responses of teachers, administrators, and ICT support staff on the current level of teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja, Nigeria.
7. Organizing regular AI-focused workshops, providing necessary infrastructure, incorporating AI modules in teacher education, offering incentives, ensuring continuous ICT support, and integrating AI goals into performance evaluations were identified as strategies for enhancing teachers' readiness to adopt AI in implementing the MVMW curriculum in FCT Abuja, Nigeria.
8. There was no significant difference among the mean responses of teachers, administrators, and ICT support staff on strategies for enhancing teachers' readiness to utilize AI in implementing the MVMW curriculum in FCT, Abuja, Nigeria

Discussion of Findings

Findings on the current level of teachers' readiness to utilize AI in implementing the MVMW curriculum revealed that teachers in technical colleges and Vocational Enterprises Institutes (VEIs) in the Federal Capital Territory (FCT), Abuja, lacked adequate preparedness. This suggests that while there may be a general awareness of AI, teachers have not received the required training, infrastructural support, or capacity-building interventions necessary for effective integration into curriculum delivery. This finding corroborates the work of Yusuf and Onasanya (2020), who reported that teachers in public technical institutions in Nigeria generally have low technological readiness due to inadequate training and poor ICT infrastructure. Similarly, Okolie *et al*. (2021) found that even when teachers have positive attitudes toward emerging technologies like AI, the absence of institutional support often hinders their ability to integrate such tools into teaching practices. In contrast, studies in more developed educational environments such as the findings of Lee and Lee (2022) in South Korea demonstrate higher readiness levels due to deliberate government investment in teacher AI literacy and infrastructure. The implication of this finding is that unless deliberate and strategic measures are taken to train teachers, provide infrastructural support, and embed AI content into ongoing professional development programs, the potential benefits of AI in improving the implementation of MVMW curriculum may not be realized in FCT Abuja.

The study further revealed that there was no significant difference in the perceptions of teachers, administrators, and ICT support staff regarding the current level of AI readiness among teachers. This uniformity of opinion across stakeholder groups suggests a shared understanding of the challenges facing AI integration in technical education within the FCT. It also validates the earlier finding of inadequate readiness, reinforcing the idea that the issue is systemic and not isolated to one stakeholder category. This finding supports the work of Afolabi and Akinbobola (2020), who observed that successful AI integration requires alignment and shared perspectives among key educational stakeholders. When various

groups—especially those directly involved in teaching, managing, and supporting technical education—agree on the state of readiness, it becomes easier to design collective interventions that address commonly identified gaps. However, this result contrasts with findings by Nwachukwu and Ede (2021), who reported divergent views among Nigerian school stakeholders, attributing the differences to communication gaps and inconsistent policy dissemination. The finding provides a unified platform for policymakers and school leaders to build collaborative capacity-building programs and implement inclusive strategies to improve readiness.

Findings on strategies for enhancing teachers' readiness to utilize AI in the implementation of the MVMW curriculum in FCT, Abuja revealed the importance of a multifaceted, systemic approach. The strategies identified emphasize both capacity-building and institutional support, including continuous training, provision of resources, curricular reforms in teacher education, and motivational frameworks like incentives and performance-based evaluations. This finding aligns with Adebayo and Mohammed (2020), who emphasized that sustainable adoption of educational technology in Nigerian technical schools depends on institutional commitment to teacher training and resource provision. Similarly, Gokhale and Machina (2021) suggested that AI readiness is significantly enhanced when teachers have access to practical training, ongoing support, and feel institutionally motivated. Moreover, incorporating AI modules in teacher training institutions, as recommended by Oyeleke and Bello (2019), is essential in preparing the next generation of educators with future-focused digital competencies. Contrary to this, some studies such as Chigona *et al*. (2016) in South Africa noted that even with workshops and incentives, a lack of follow-up support and unclear policy directions may limit long-term adoption. This implies that while the strategies identified in this study are relevant and potentially impactful, their implementation must be deliberate, continuous, and coordinated to ensure meaningful teacher engagement with AI tools in implementing MVMW curriculum.

The finding that there was no significant difference among teachers, administrators, and ICT support staff regarding the strategies for improving AI readiness suggests a consensus among key stakeholders. This shared perception implies that all groups recognize the existing gaps and agree on the practical steps necessary to support teachers in integrating AI into technical teaching, particularly in MVMW. Such uniformity across stakeholder categories is consistent with the findings of Lawal and Agommuoh (2022), who reported that stakeholder alignment on intervention strategies significantly contributes to the success of technology adoption in educational systems. It also supports the argument of Eze and Okoli (2020) that consensus among institutional actors facilitates policy uptake and eases the process of resource allocation and collaborative planning. Conversely, in studies like that of Tella and Afolabi (2019), differing views among stakeholders hindered the implementation of ICT innovations due to conflicts in priority and execution approaches. The implication of this unified response is that it provides a solid foundation for the design and rollout of comprehensive AI readiness programs, as institutions can move forward with minimal resistance from internal stakeholders.

Conclusion

This study critically assessed the current level of teachers' readiness to utilize Artificial Intelligence (AI) in implementing the Motor Vehicle Mechanics Work (MVMW) curriculum in technical colleges and Vocational Enterprise Institutions (VEIs) across the Federal Capital Territory (FCT), Abuja, Nigeria. The findings revealed a generally low level of readiness among teachers, as evidenced by their limited familiarity with AI concepts, inadequate training, lack of infrastructure, and low confidence in applying AI tools in teaching. Despite this, teachers expressed a willingness to adopt AI if adequately supported. Moreover, the

study identified strategic interventions that can bridge the readiness gap, including regular AI-focused professional development, provision of AI-related infrastructure, incorporation of AI in teacher education programs, continuous technical support, incentive-based motivation, and aligning AI integration with performance appraisal systems. These findings implied that, without proactive efforts to improve teacher readiness, the potential benefits of AI in implementing MVMW curriculum will remain largely unrealized. Therefore, a strategic and inclusive response is critical for fostering innovation, improving educational quality, and preparing Nigeria's technical workforce for the demands of 21st century.

Recommendations

Based on the findings of the study, the following recommendations were made:

I. The Federal Ministry of Education and the National Board for Technical Education (NBTE) should initiate targeted capacity-building programs for teachers that provide hands-on training in AI tools relevant to MVMW instruction.
J. The institutional heads in technical colleges and vocational centers should introduce regular AI workshops, and collaborate with teacher education institutions to integrate AI modules into preservice training.

References

Adebayo, F. A., & Mohammed, I. (2020). Teacher capacity-building for digital literacy in Nigerian vocational education: Challenges and solutions. *International Journal of Educational Research and Development, 15*(3), 112–124.

Afolabi, A. O., & Akinbobola, A. O. (2020). Stakeholder perspectives on ICT integration in Nigerian schools. *Journal of Educational Development and Technology, 11*(2), 78–85.

Agbo, I. S., & Ogbuanya, T. C. (2021). Barriers to integrating emerging technologies in Nigerian technical education: A case study of automobile workshops. *International Journal of Vocational and Technical Education, 13*(1), 20–30. https://doi.org/10.5897/IJVTE2021.0291

Alhassan, A., & Bello, Y. A. (2023). Readiness of Nigerian vocational educators for digital technology integration: A case study of selected technical colleges. *Journal of Technical Education Research, 15*(1), 45–59.

Bello, S., & Garba, H. (2023). Artificial Intelligence in Technical Education: A Nigerian Perspective. *African Journal of Educational Technology, 9*(2), 77–88.

Chigona, A., Chigona, W., & Davids, Z. (2016). Empowering teachers for technology integration: A South African perspective. *Journal of African Education Studies, 10*(1), 34–48.

Eze, S. C., & Okoli, R. N. (2020). Stakeholder collaboration in Nigerian ICT education policy implementation. *African Journal of Education Policy, 25*(2), 67–83.

Ghavifekr, S., & Rosdy, W. A. W. (2015). Teaching and learning with technology: Effectiveness of ICT integration in schools. *International Journal of Research in Education and Science (IJRES), 1*(2), 175–191. https://doi.org/10.21890/ijres.23596

Gokhale, A. A., & Machina, K. (2021). Enhancing AI readiness in vocational education: Roles of training and motivation. *Journal of Technical Education and Training, 13*(4), 28–39.

ILO. (2023). *Skills for a resilient youth workforce: Global trends and policy responses*. International Labour Organization. https://www.ilo.org/global/topics/skills/WCMS_869679/lang--en/index.htm

Lawal, A. A., & Agommuoh, P. C. (2022). Stakeholder perspectives on digital transformation in Nigerian technical colleges. *International Journal of Vocational and Technical Education, 14*(2), 58–70.

Lee, J., & Lee, H. (2022). Enhancing teacher readiness for AI integration in vocational education: A Korean model. *Journal of Educational Technology and Society, 25*(1), 34–45.

National Board for Technical Education (NBTE). (2013). *Curriculum for Motor Vehicle Mechanic Work (National Vocational Certificate).* NBTE.

Nwachukwu, C. E., & Ede, E. O. (2021). Disparities in stakeholders' perceptions of digital readiness in Nigerian secondary schools. *International Journal of Education and Innovation, 4*(3), 15–27.

Okolie, U. C., Igwe, P. A., & Elom, M. C. (2021). Adoption of digital tools in Nigerian technical education: Challenges and perspectives. *International Journal of Vocational and Technical Education, 13*(1), 11–23.

Okonkwo, A., & Ibrahim, M. Y. (2024). Revitalizing Nigeria's TVET through emerging technologies: Policy, practice, and prospects. *Journal of Contemporary Educational Research, 6*(1), 45–59.

Oladiran, A., & Ajayi, A. A. (2023). Integrating EdTech into Nigerian technical colleges: Challenges and policy recommendations. *Nigerian Journal of Vocational Studies, 15*(2), 33–47.

Oyeleke, A. O., & Bello, M. A. (2019). Curricular reforms for AI inclusion in Nigerian teacher education programs. *Nigerian Journal of Educational Technology, 29*(1), 91–104.

Russell, S., & Norvig, P. (2016). *Artificial Intelligence: A Modern Approach (3rd ed.).* Pearson Education.

Tella, A., & Afolabi, O. (2019). Challenges to ICT integration in Nigerian education: The role of stakeholder perception. *Nigerian Journal of Educational Research, 25*(1), 22–39.

Umar, L., & Danladi, S. (2022). Reforming Nigerian technical education through digital innovation: Lessons from emerging economies. *Journal of African Educational Research, 8*(1), 54–70.

UNESCO. (2022). *Artificial Intelligence in education: Challenges and opportunities for sustainable development*. United Nations Educational, Scientific and Cultural Organization.

Yusuf, M. O., & Onasanya, S. A. (2020). Teachers' readiness for ICT integration in education: A national survey. *Nigerian Journal of Educational Media and Technology, 24*(2), 1–15.

SUB-THEME 6

AUTOMOBILE TECHNOLOGY

THE EXTENT OF UTILIZATION OF DIGITAL SKILLS AND ARTIFICIAL INTELLIGENCE TOOLS FOR EFFECTIVE DIAGNOSING OF AUTOMOBILE SYSTEMS AMONG TECHNICIANS IN BENUE STATE

Orbula Joshua Tertsegha
orbulatertsegha18@gmail.com
07060819646
Department of Automobile Technology
School Of Technical Education
Federal College of Education (Technical) Isu, Ebonyi State.
Jacob Ibrahim
Bissallahibrahimj@gmail.com
07062754090
Department Of Automobile Technology
School of Technical Education
Federal College of Education (Technical) Ekiadolor, Benin, Edo State.
Danjuma Adamu
Danjumaadamu303@gmail.com
08034902805
Department of Mechanical and Aerospace Ground Engineering
Airforce Institute of Technology, Nigerian Airforce Kaduna

Abstract

The study was designed to determine the utilization of digital skills and artificial intelligence tools for effective diagnosing of automobile systems among technicians in Benue State. Two research questions were designed for the study and descriptive survey research design was adopted for the study. The study was conducted in Benue State and a total of 50 respondents were used in answering 19 structured questionnaire items develop for the study. The questionnaire items were face validated by three experts. The internal consistency of the entire 19 item questionnaire was determined to be 0.85and 0.81 using Cronbach alpha method. The 19 copies of the questionnaire were administered to the respondents with the help of three research assistants. Mean and standard deviation were used to answer the research questions. The findings of the study revealed among others that most of the AI tools listed are not utilized while the challenges of utilizing AI tools were obvious. Based on the findings it was recommended among others that: Nigerian Automobile Technician Association (NATA) should regulate and ensure that, technicians are AI compliance as well as sent on regular update courses so as to update their knowledge about AI tools meant for diagnosing.

Introduction

Automobile Technology as a course is offered basically to focus on preparing individuals for productivity and development of the nation. Specifically, it provides trained manpower in automobile technology as well as industries, provision of skills needed for maintenance of automobiles and for economic development (Federal Republic of Nigeria, 2020). Therefore, Automobile is a self-propelled vehicle used for transportation of goods and passengers on land Giri (2015). In general, modern automobile is a complex form of machine which

comprises of the chassis and the body, the chassis is made of a supporting body, power unit, clutch or fluid coupling, transmission system and control systems while wheels and tires with other suspension systems supports the frame and it is propelled on the road due to friction between the tires and the road surface. Giri (2015) stated that, automobile of today is the culmination of many years of pioneering research and development.

This implies that, it is a highly sophisticated machine which includes multi efficient and reliable mechanical, electrical and electronic devices. Sophisticated technology invention of automobile consists of digital instrument panel, antitheft track, automatic gears, and bonnet rain detectors which automatically activate the windscreen wipers. A network of computer controls are installed to signal the electronic control unit (ECU) so as to adjust to the road conditions for perfect driving. This new Technology has continue to evolve and is increasing yearly because innovations resulting from advanced technology kept on emerging in automobile industry. The modern automobile is quite different from the automobile in those days because recently significant changes have continue to occur and there are fewer emissions and less pollution when compared to the past and this is in line with Sager and Vijay (2019) who stated that, electronic and computer monitoring systems provide a means of checking and controlling emissions while improving fuel efficiency. Considering the above, it can be notice that automobile have gone digital now more than in the past because many of the functional parts of an automobile today have evolved from being mechanical (control by pressure valves) to electronic components which is incorporated to monitor emission and improve fuel efficiency. Also, electronic sensors with actuators are installed to communicate with Electronic Control Unit (ECU) for optimal performance and the emergence of electronic devices on automobile have pave way for the necessary digital skills and artificial intelligence tools to use for optimal diagnosing.

In the light of this, modern automobile is made up of complex electronic components which need digital skills for easy maintenance. Also, different researches are carried out by researchers in the automobile industry because of the subsystems in existence on automobile today as a result of air pollution, safety legislation, inefficiency etcetera etcetera. The results of these researches in the field of automobile engineering necessitated the emergence of autotronics which focused on prompting automobile technicians to brainstorm together to ensure that the necessary digital skills and AI tools are acquired to carry out diagnoses in automobile by technicians because they need to acquire requisite skills in diagnosing techniques in order to troubleshoot Ogumilade (2017). Hence automobile system of a vehicle required routine diagnosing and maintenance by automobile technicians.

Technicians are professionals trained in the area of automobile to inspect, maintain and repair automobiles. The major responsibility of automobile technicians is to repair simple and high level technology related works in automobile. The complex electronic part of automobile requires technicians with digital skills in order to carry out diagnoses properly. Therefore, integrated electronic systems and complex computers regulate vehicles and their performance while on the road. Technicians must have a broad knowledge of the complexity of components of various vehicles; they must be able to work with electronic diagnostics equipment, digital manuals and reference materials. Technicians must be knowledgeable about internet or software packages to receive updates from the manufacturer's service information and other data base this will make them to be current with industrial standards. Considering the complexity nature of vehicle components, it can be seen that automobile technicians require digital skills and artificial intelligence for optimal performance.

Artificial Intelligence (AI) has become necessary in contemporary daily existence. The most prevalent instances include smartphones, Google's search engine, promotional activities, and social media platforms Elliot *et al* (2019). It involves using machine learning (ML) and deep learning (DL) techniques to analyze real-time data collected from various sensors installed in the vehicle Bedi *et al* (2022). The sensors collect data from various vehicle systems, which are subsequently analyzed by Algorithms to detect any faults, anomalies or deviations from expected performance levels. Therefore, AI tools used in automobile includes ML and DL which have been extensively used for fault detection and diagnosis in electric vehicle (EV) motors, with a focus on feature extraction and fault classification Lang *et al* (2021). Another AI tool used in automobile is ChatGPT it can be used in answering common problems technician encounter while repairing vehicles. Eg problems can be type for possible causes and solution. It can also provide technician with technical information about different vehicles and their components especially when a technician is working on a vehicle he has little or no knowledge about its parts before, chat GPT can get information about its engine, transmission and critical components. It also provides maintenance tips. Other AI tools includes machine learning based diagnostics tools, AI powered inspection tools, Robotic inspection system, Chatbots, AIventic for field companies, Generative AI tools and among others. However, advances in AI have paved way for the emergence of specialist and various AI approaches, including machine learning (ML) which presents promising solutions to enhance diagnostics accuracy which enable predictive maintenance and adapt evolving vehicle complexities. Considering the above about AI tools its pertinent that technicians should possess digital skills in order to operate scan tool and other AI tools for proper diagnosing.

Digital skills are the ability to use new technologies, devices, applications, and networks with knowledge of the facts. Although in recent years the question of acquiring digital skills by automobile technicians has become increasingly topical and pressing Drakka *et al* (2022). Digital skills have become necessary for automobile technicians in order to be able to operate technological inclined tools like diagnostics scan tools, AI GPTChat tools and among others. Ever Since the introduction of computers, networks, servers, and even electronics in automobile diagnosing in the field requires the presence of professionals capable of dealing with these tools. Digital skill is necessary and has become part of the modern automobile. Hence there is every need to embrace it by all automobile technicians for optimal diagnosing

Diagnosing is the process of tracing a fault by means of its symptoms, applying knowledge and equipment to analyze and test results Tom (2016). This implies that diagnosing is important in identifying and resolving issues with modern vehicles in order to perform effective repairs. In supporting the need for vehicle diagnoses, Akpakpavi (2014) stated that modern automobile is a blend of 20th and 21st century technology and hence need diagnoses for effective maintenance. Therefore, efficient automobile system fault detection is a complex process which needs high level of understanding digital skills owing to the fact that it is prone to various faults due to more complex integration of electromechanical components being used in the automobile industry to provide convenience, efficient performance and comfort to the passengers. However, in the recent past mechanics used to carry out diagnoses based on experience and symptoms noticed or developed Ogbuanya and Usman (2020).This implies that, diagnosing then was through trial and error method all along. This development resulted in poor execution of jobs, unnecessary replacement of parts that could not have been removed and poor acquisition of skills as a result of inadequate requisite digital skills and artificial intelligence tools. Therefore, in order to improve on fault finding in automobile this lead to the advent of diagnosing tools and equipment such as Onboard Diagnostic Scan tool (OBD

II), Digital multimeter, exhaust gas analyzer, continuity tester, plug and coil ignition tester, MT-900 Autoscope, Current leakage tester, circuit defective tester among others Bosch (2022) which requires digital skills. In light of this, it's pertinent to utilize artificial intelligence tools and digital skills for proper diagnosing.

Utilization of digital skills and artificial intelligence is the way of measuring how efficient and productive the digital skills and artificial intelligence are, this includes amount of time a piece of tool and equipment is effectively used and equipment meant to be utilized and diagnose automobile systems which enable technicians to acquire facts, competencies as well as cognitive process. The success of achieving the desire objectives in automobile systems depends on the suitability and effective utilization of requisite skills and equipment to accomplish tasks such as diagnosing, clearing faults codes and carrying out repairs. According to the Nigerian Education and Research Development NERDC (2022) the automobile program is inherently workshop based and calls for adequate acquisition of digital skills and utilization of artificial intelligence.

Statement of the Problem

One of the objectives of diagnosing automobile is to impart the necessary skills needed to make technicians to acquire more skills. Therefore, technicians are expected to possess digital skills through the use of AI tools for proper repair, diagnoses and have the necessary diagnosing AI tools to enhance practical skills. It is notably that, tools and equipment meant for diagnosing automobile are written in some literatures and have also been used by technicians especially in big cities.

However, despite the introduction of AI tools for diagnosing to enhance digital skills, it seem auto technicians are not aware of the tools or does not possess the digital skills to use the modern tools in most of the workshops in Benue State because the continual use of old method of diagnosing automobile by technicians is a major source of worry to the researcher. This is because they lack digital skills as well as competencies in diagnosing automobile systems and these results to inefficient diagnosis by technicians which they rely on traditional method of diagnosing, relatedly; it reduced accuracy because without AI-powered tools technicians may struggle to identify complex issues leading to incorrect diagnoses and repairs. Also, technicians who don't adopt digital skills and AI tools may fall behind competitors who leverage these technologies.

The problem may be attributed to critical factors which might not have been properly addressed such as level of understanding digital skills among automobile technicians, technicians' ability to use AI tools and digital technologies for diagnosing automobile. This statement of the problem highlights the need for research and intervention to address the skills gap and improve the utilization of digital skills and AI tools among automobile technicians. Hence, the study is design to determine the Utilization of digital skills and artificial intelligence tools for effective diagnosing of automobile systems among technicians in Benue State.

Aims and Objectives of the study

Specifically, the study sought to:

1. Examine the extent of utilization of AI tools to acquire digital skills among automobile technicians in Benue State.
2. To identify the challenges of using digital skills and AI tools for diagnosing automobile among technicians in Benue State.

Research Questions

The following research questions were formulated to guide the execution of the study:

1. What is the extent of utilization of AI tools to acquire digital skills among technicians in Benue State?
2. What are the challenges of using digital skills and AI tools for diagnosing automobile among technicians in Benue State?

Methodology

Descriptive survey research design was used for this study. The study was carried out in Benue State. The population of the study consists of 50 registered technicians with Nigerian Automobile Technician Association (NATA) across various branches in Benue State mostly from Benue links, Pleasure travels company LTD, as well as the tertiary institutions offering automobile from Benue State. Due to the manageable size of the population, all the 50 respondents were used for the study. Hence, no sampling technique was employed in the selection of the respondents. The instrument used for data collection was a structured questionnaire titled: "Extent of Utilization of Digital Skills and Artificial Intelligence Tools for Effective Diagnosing of Automobile Systems" (EUDSAITEDAS) developed by the researcher and designed on four-point scale with responses: Very Highly Utilize (VHU) = 3.50-4.49, Highly Utilize (HU)= 2.50-3.49, Moderately Utilize (MU) = 1.50-2.49, Not Utilize (NU)=1.00-1.49

The same rating scale is applicable to scales such as Strongly Agree (SA), Agree (A), Disagree (D), Strongly Disagree (SD) with numerical values of 4, 3, 2, and 1, respectively. The instrument consists of two sections, A and B. Section A is design to collect personal information of the respondents based on respondents status. Similarly, section B-C seeks for respondents opinions on the relevant research questions developed in line with the purpose of the study. The instrument was face validated by three experts in TVET. Cronbach Alpha statistical technique was used to determine the reliability of the instrument and yielded 0.85, 0.81 coefficients for the two sections. The study employed the use of mean and standard deviation to answer the research questions.

Results

Research Question One

What is the extent of utilization of AI tools to acquire digital skills among technicians in Benue State?

Table 1: Mean and standard deviation of respondents on the extent of utilization of digital skills and AI tools for diagnosing automobile

The analysis in Table 1 reveals the mean and standard deviation of responses from the

			N=50	
SN	**ITEMS**	$\bar{x}$	**SD**	**Remark**
1	Maintenance Robotic	1.20	0.51	NU
2	GPTchat	2.48	0.58	MU
3	Diagnostics Scan Tools	3.51	0.61	VHU
4	Machine Learning Based Diagnostics Tools	1.48	0.54	NU
5	Aiventic	1.41	0.51	NU
6	AI Predictive maintenance Platforms	1.41	0.52	NU
7	Generative AI for repair instructions	1.45	0.55	NU
8	Application soft ware	1.61	0.53	MU
9	Internet of thing asset service management solution	1.54	0.55	MU
	Grand Mean and SD	**1.78**	**0.54**	**MU**

Key: N = Number of respondents; $\bar{x}$ = mean; VHU = Very Highly Utilize; HU= Highly Utilize; MU = Moderately Utilize; NU= Not Utilize

respondents on nine (9) items posed to determine the extent of utilization of AI tools to acquire digital skills among technicians with a grand mean of 1.78. This implies that most of the items are moderately utilize as regards the extent of utilization of AI tools. Similarly, the average standard deviation obtained was 0.54 with ranges from 0.51-0.61 which is less than 1.96 meaning the respondents were not too far from the mean and were close to one another in their responses. This closeness of the respondents adds value to the reliability of the mean.

Research Question Two

What are the challenges of using digital skills and AI tools for diagnosing automobile among technicians in Benue State?

Table 2: Mean and standard deviation of respondents on the challenges of using digital skills and AI tools for diagnosing automobile

				N=50
S/N	**ITEMS**	$\bar{x}$	**SD**	**Remark**
1	Poor network quality	3.75	0.58	SA
2	Lack of resources	3.73	0.69	SA
3	Lack of sufficient technical knowledge to AI tools	3.49	0.68	A
4	Technicians does not incorporate digital skills culture	3.19	0.64	A
5	Resistance to apply AI tools	3.41	0.69	A
6	Unavailability of AI tools	3.75	0.70	D
7	Non availability of steady power supply	3.49	0.67	A
8	Inability of the relevant bodies to regulate and ensure that AI tools are on ground before establishing workshops.	3.41	0.69	A A
9	Limited knowledge of AI	3.42	0.65	A
10	AI software malfunction	3.39	0.64	A
	Grand Mean and SD	**3.50**	**0.66**	**SA**

Key: N = Number of respondents; $\bar{x}$ = mean; SD = Standard Deviation; SA = Strongly Agree; A = Agree; D= Disagree; SD= Strongly Disagree.

Table 2 shows the mean responses of the respondents on ten (10) items posed to determine the challenges of using digital skills and AI tools for diagnosing automobile with a grand mean of 3.50. This implies that most of the items have agreed as regard the challenges of using digital skills as well as AI tools. The average standard deviation of their responses was 0.66 with ranges from 0.58-0.70 which is not above the normal standard deviate (1.96), implying that their responses on the items were not too different from each other but close to one another in their responses. This closeness of the respondents shows how reliable the mean obtained was.

Discussion of findings

Findings from research question one in Table1 revealed that respondents moderately make use of the nine items and four out of the nine items were not utilize. This implies that technicians are still utilizing the traditional method of diagnosing automobile. Orbula (2023) asserted that, it's not proper for technicians to carryout diagnoses through traditional method as the habit leads to damages of parts as well as time consuming.

Findings from research question two in table 2 indicates that respondents have agreed on almost all the items as regards to the challenges of using digital skills and AI tools to carryout diagnoses. This implies that, technician needs to improve on the stated items in table 2 above. Ahmadian, *et al* (2023) asserted that 21st century mechanics should embrace the use of modern tools for proper diagnosing. This will prompt them to be conversant with the use of modern technology.

Conclusion

The paper has clearly proves that digital skills has become necessary in tackling diagnosing in automobile. Therefore, for effective diagnoses in automobile, technicians needs to acquire digital skills through the use of AI tools. Regulatory body such as NATA should ensure that, technicians are AI compliance as well as sent on regular update courses so as to update their knowledge about AI tools meant for diagnosing.

Recommendations

1. Nigerian Automobile Technician Association (NATA) should regulate and ensure that, technicians are AI compliance as well as sent on regular update courses so as to update their knowledge about AI tools meant for diagnosing.
2. Government should make strict policies to ensure implementation of digital skills and AI tools in institutions offering automobile courses.

References

Ahmadian, S. Alabdullah, T. T., Y., & Motaghian, I. (2023). Maintenance and repairs system of automotive industry for sustainable internationalization. *International Journal on Advanced Technology, Engineering, and Information System*, *2*(2), 106-123.

Akanbi, G.O. (2017). Prospects for technical and vocational education and training (TVET) in Nigeria; Bridging the gap between Policy Document and implementation. *The International Educational Journal on Comparative Perspective 16(2), 1-15.*

Akpakpavi, M. (2014). Modern automobile vehicle repair practices in micro small and medium scale garages in Ghana. *International journal of science, technology and Society*, 2(6), 216-222.

Bedi, P. Goyal, S.B., Kumar J. Choudhary, S. (2022). Smart automobile health monitoring system. In multimedia technologies in the internet of things environment. Singapore: Springer 127-460.

Bosch, R. (2022). *Automotive Hand Book* 11thedition. UK: willey publishers.

Drakaki M, Karnavas, Y.L, Tziafettas, I.A,Linardos V, Tzianas P.(2022). Machine learning and deep learning based methods toward industry, predictive maintenance in induction motors; state of the art survey. Jind eng manag. 15(1), 31-57.

Elliot, A. (2019). The culture of AI: everyday life and the digital revolution. London Routledge doi 10,4324/9781315387185.s

Federal Republic of Nigeria(2020). *National policy on education* (6thed). Lagos: Nigerian Educational Research and Development Council (NERDC), 12.

Giri, N.K. (2015). *Automobile Mechanics*.NewDelhi: Khanna publishers 10th edition.

Lang, W. Hu,Y. Gong, C. Zhang, X. Xu, H. Deng, J. (2021). Artificial intelligence base technique for fault detection and diagnosis of EV motors: a review. *IEEE transport electric* 8(1) 384-406.

Nigerian Educational Research and Development Council NERDC (2022). *Motor vehicle mechanics senior secondary school curriculum* NERDC ABUJA.

Ogbuanya, T. C., & Usman, D., A. (2020). Assessment of instructional facilities in implementing the contents of the motor vehicle mechanics work Curriculum in technical colleges in North Central Nigeria. *Jurnal Pendidikan Teknologidan Kejuruan*, *26*(2), 95-106.

Ogunmilade, O.J. (2017). Core skills required by graduates of motor vehicle mechanics work for maintaning anti-Lock braking system of modern cars in Lagos State. *International Journal of Vocational and Technical Education Research* 3 (1)1-11.

Olugbade, S. Ojo, S. Imoize A.L., Isabona J., Alaba, M.O.(2022). A review of artificial intelligence and machine learning for incident detectors in road transport systems. Maths comput app 27(5); 77

Orbula, J.T. (2023). Adequacy, Functionality and Utilization of modern workshop tools for effective diagnosing of automobile systems in higher institutions in Benue State. *TEPAN annual national conference Oyo*

Sager, S.D., & Vijay, O.S. (2019). Recent Trends in Automobile Engineering. *HBRP Publication* 2(3) 35-45

Tom, D. (2016). *Advance Automotive Fault Diagnosis*. London:Routledge publishers.

SKILLS REQUIRED BY AUTOMOBILE TECHNOLOGY UNIVERSITY GRADUATES IN DIAGNOSING AUTO-ELECTRICAL FAULTS IN MOTOR VEHICLES IN EDO STATE, NIGERIA

DR. S.O. OSUYI
AND
F.O. AIZEBEOJE
DEPARTMENT OF INDUSTRIAL TECHNICAL EDUCATION,
FACULTY OF VOCATIONAL AND TECHNICAL EDUCATION,
UNIVERSITY OF BENIN
Sunday.osuyi@uniben.edu
aizefranklyn@gmail.com

Abstract

The study ascertained the skills required by automobile technology graduates for diagnosing auto-electrical faults in motor vehicles in Edo State, Nigeria. Two research questions guided the study and one null hypothesis was tested at .05 level of significance.
The research design adopted for the study was descriptive survey. The population of the study which was also the sample size comprised 121 registered employers of labour in the automobile industry in Edo State.. The instrument used was validated by three experts and it had a reliability coefficient of 0.75. Analysis of data was done using Mean ($\bar{X}$), Standard Deviation (SD) and z-test statistics.The findings revealed that employers of labour agreed that: the listed skills are required by automobile technology graduates for diagnosing auto-electrical faults in motor vehicles; and that the listed factors influenced the acquisition of skills required by automobile technology graduates for diagnosing auto-electrical faults in motor vehicles. It was concluded that the skills required by automobile technology graduates for diagnosing auto-electrical faults in motor vehicles as agreed by employers of labour in the automobile industry are; diagnosing and trouble-shooting amongst others while the factors that influence the acquisition of these skills are mismatch between university automobile technology curriculum content. It was also revealed that male and female employers of labour in the automobile industry were not significantly difference in their opinions on the factors influencing skills acquisition by graduates of automobile technology graduates. Based on the findings, it was recommended that there should be collaboration between automobile industries and institutions offering automobile technology progrmme for relevant curriculum content.
Key words: Automobile Technology, Skill, Auto-electrical faults

Introduction

Automobile Technology is one of the courses offered in Nigerian Universities. It is offered as a unit programme with several courses in the department of Vocational and Technical Education, Faculty of Education. However, in recent times, the department of Vocational and Technical Education has been upgraded to Faculty of Vocational and Technical Education in many Nigerian universities including university of Benin. The courses offered in automobile technology programme include: Engine Layout, Fuel and Ignition Systems, Exhaust System, Suspension Systems, Braking Systems, Transmission Systems and Auto Electricity amongst others. Automobile Technology graduates are expected to be acquainted with skills in diagnosing faults in these various systems using modern equipment that are electronically operated.

According to Denton (2017), automobile technology programme is aimed at training graduates to diagnose and repair vehicle systems, especially electrical faults. The author added that the objectives of automobile technology education focus on equipping students with the knowledge and skills to design, maintain, diagnose and repair modern vehicles, particularly addressing complex auto-electrical systems while adapting to technological advancements like electric vehicles (EVs) and autonomous systems. As vehicles become increasingly complex, technicians must keep up with the latest technological advancements and industry trends.

In order to achieve these laudable objectives, automobile technology students must be taught with the relevant methods and facilities that would make them to be acquainted with both the theoretical and practical skills needed for repair and servicing of motor vehicles. These measures are expected to produce quality graduates of technical education.
The quality of technical education graduates has been a major source of concern by most employers in the Nigerian labour market and they expressed their dissatisfaction about the level of skills possessed by university graduates of automobile technology. Automobile Technology like other engineering professions has witnessed changes and expansion at an accelerated rate in the last three decades. The automobile industry is undergoing rapid technological transformation and is currently faced with increased deregulation, accelerating globalization, and ever-changing consumer tastes. According to Dennis (2022), we are experiencing changes at an increasingly rapid pace in many aspects of our lives, with everything moving fast. Such rapid changes in the workplace and industries are forcing educational systems into a tight corner. For example, the use of computerized and electronic tools in the repair of motor vehicles has increasingly become an integral part of the process in the automobile industry (Kitainge, 2015).

Unlike motor vehicles manufactured before the year 2000, all millennium motor vehicles have similar features. Virtually all the systems are controlled by electronic circuit devices known as “Sensors”. These sensors are electronic devices that monitor and measure various parameters of a motor vehicles operation and environment, sending data to the vehicles control systems to optimize performance, safety and efficiency. It means that every system has a sensor. For example, the brake system sensor is able to monitor and detect worn out brake pads thereby switching ‘ON’ the caution light on the dashboard. Another sensor is responsible for monitoring the level of lubricating oil in the engine, level of water in the radiator and temperature of the engine. The different sensors are connected to a common electronic device known as “Brain Box”. As the name implies, the brain box of millennium motor vehicles is the brain that controls the functioning of the whole systems, however, some motor vehicles are designed with more than one brain boxes. These electronic circuits make the repair of millennium motor vehicles more complex. Different faults developed by motor vehicles have similar symptoms. For example, if the engine fails to start, even if the battery is fully charged, the fault could be caused by the ignition or fuel system. Before this era of electronic control systems, it was common with motor vehicle mechanics to carry out such troubleshooting by trial and error which is energy sapping and time consuming.

Marcu and Pop (2024) opined that in modern motor vehicles, faults are easily diagnosed with the use of diagnostic tools known as ‘Expert Systems’. This tool is of various capacities and designs. It is purely an electronic equipment which has a signal detector and a separate monitor like a laptop computer screen that displays the code of every system in the motor vehicle. If the tool is correctly manipulated with the code, the fault in a particular system or unit is displayed on the screen. The motor vehicle mechanic including automobile technology graduates need to be acquainted with the knowledge and skills

required to manipulate this diagnostic tool known as expert system for effective repair and servicing of modern motor vehicles.

According to Init (2019), possession of job specific skills in the automobile technology course alone is not enough to guarantee a graduate of automobile technology to obtain, retain and progress on the job. There is need for automobile technology graduates to be acquainted with the design of modern motor vehicle systems that are designed to function with electronic circuits. The author classified skills needed by graduates of auto mobile technology into two; technical skills and Practical and Soft skills. In the technical skills, the graduate are expected to be acquainted with diagnostic and trouble shooting skills, wiring diagrams interpretation skills, electrical and electronic system knowledge, component knowledge skills, repair and installation skills, safety awareness' skills, among others. The second category of skills require by auto electrical graduates is Practical and soft skills. They include: problem solving and trouble shooting skills, attention to details, hand-eye coordination, communication skills, ability work independently and as a team, customer service and time management skills. According to Init (2019), learners are expected to be equipped with the knowledge, attitudes and skills necessary to match the pace of the technology changes in the industry all over the world. It is a well-known fact that effective training in skill acquisition has immensely contributed to the technological excellence and economic self-reliance of the industrialized nation. It is for this reason that Ezeji and Okorie (2018) while stressing the importance of skill acquisition in national growth, emphatically contended that Nigeria's social and economic problems will be drastically reduced if people are given adequate vocational training in skills, raw materials, machineries and equipment. But Jimoh (2017) observed that technical education graduates of Automobile Technology programmes lack practical skills and are not carrying out maintenance work to the expectations and satisfaction of their employer.

Osuala, (2018) defined skill as the ability to perform tasks expertly. Atsumbe (2020) opined that there is a trend of unemployment and under-employment probably occasioned by the mismatch between skill demands in the workplace and those provided by the schools and that skill acquisition is affected by certain factors. According to Poka (2023), factors influencing acquisition of skills needed by automobile graduates are: the mismatch between university automobile technology curriculum content and workplace needs, the difference between learning environment (school workshop) and workplace environment, use of outdated and obsolete equipment in training, use of teachers that have no practical skills and the absence, or inadequacy of teaching and learning materials. Almaleh (2019) opined that with the advancement of technology, academics and curriculum developers are always under pressure to provide students with skills that match the market's requirements. Failure on the part of curriculum developers and implementers to provide skills that match the market requirements could amount to low quality training of graduates. Consequently, many students acquire low quality training, thereby limiting their prospects of becoming self-reliant and productive in the labour market (Kigwilu, 2017). The digital technology that is predominant in the current economy requires that the learners are well trained in practical-related skills. However, teaching practical work theoretically is a hopeless and poor teaching and learning approach in the current world that does not foster creativity and innovation of useful academic technological tools such as ICT to enhance and develop today's academic endeavors and the world (Niyitanga, 2021).

The auto-electricians' employers can either be male or female based on gender. Gender is a state of sexual orientation of an individual. According to Daluba and Audu

(2016), it is perceived that female auto-electricians might not possess requisite skills in comparison to their male counterpart largely due to public perception of the job and as such, unable to maximize the desired goals and objectives of automobile technology programme. The employers of labour in the automobile industry have been known to be "male-dominant" for ages, where females comprise of 15% and males 85%, at all levels in the automobile industry largely due to their skill levels (Denton, 2017).

Statement of the Problem

It has been observed that modern motor vehicles are largely electronically operated which is a sharp contrast from what was obtainable some decades ago wherein vehicles were operated manually. The various systems (brake, ignition, fuel, suspension, exhaust, amongst others) in motor vehicles are now electronically operated. Therefore, graduates of automobile technology are expected to be acquainted with the skills needed to diagnose auto-electrical faults in motor vehicles so that they could be relevant in the automobile industry. But the reverse seems to be the case not only in the automobile industry but in other industries as well. This is why the National Bureau of Statistics (2022) reported that there was a 33% unemployment rate in Nigeria among graduates. The report by the National Bureau of Statistics included graduates of automobile technology. This means that graduates of automobile technology seem not to be acquainted with the skills of diagnosing, servicing and repairing of modern motor vehicles. This situation might make them job seekers instead of being self-employed or even employers if labour.

If the aforementioned situation continues unabated, it is likely that more youths will be on the streets doing nothing useful. It could result to increased crime rate. With the increase in sophistication of automobiles and rapid growth in the number of motor vehicles on Nigerian roads, there is therefore need to assess the required skills needed by automobile technology graduates for diagnosing auto-electrical faults in automobile vehicles.

Purpose of the Study

The main purpose of the study was to ascertain the skills needed by automobile technology graduates for diagnosing auto-electrical faults in motor vehicles in Edo State. Specifically, the study determined:

1. Skills needed by automobile technology university graduates for diagnosing auto-electrical faults in motor vehicles.
2. Factors influencing acquisition of skills needed by automobile technology university graduates for diagnosing auto-electrical faults in motor vehicles.
3. The opinions of male and female employers of labour on auto-electrical skills needed by automobile technology university graduates.

Research Questions

The following research questions guided the study:

1. What are the skills needed by automobile technology graduates for diagnosing auto-electrical faults in motor vehicles?
2. What are the factors influencing acquisition of skills needed by automobile technology graduates for diagnosing auto-electrical faults in motor vehicles?

Hypothesis

One null hypothesis was formulated and tested at 0.05 level of significance;

1. There is no significant difference between the opinion of male and female employers on the skills needed by automobile technology graduates for diagnosing auto-electrical faults in motor vehicles.

Methodology

The design of this study was descriptive survey research. It is employed in the gathering of information about prevailing conditions or situations from a representative sample of the population for the purpose of description and interpretation for generalization (Nworgu in Gabari, 2018). This design is suitable for this study in the sense that registered employers of labour used in this study are the representative of all the employers of labour in the automobile industry in Edo State.

The population of the study comprised 121 registered employers of labour in the automobile industry in Edo State, Nigeria. It was made available to the researcher by Small and Medium Scale Development Agency (SMEDAN, 2023), Benin City, Edo State. The sample size was 121 employers of labour in the automobile industry. There was no sampling because the population was manageable, hence census.

The instrument for data collection for this study was structured questionnaire which was developed by the researcher based on the literature reviewed "Skills Needed by Automobile Technology Graduates Questionnaire" (SNATGQ). The questionnaire had two sections, A and B. section A contained the demographic information of the respondents such as sex. Section B contained the item statements according to the number of research questions. Research question 1 was rated on a four point rating scale as: Very Highly required, Highly Required, Required, sometimes required and Very Highly. Research question 2 was rated on four a point rating scale of Very Highly Influence, Highly Influence, Moderate Influence, Little Influence, weighted 4, 3, 2 and 1 respectively.

The instrument was validated by three experts all in the Faculty of Vocational Technical Education, University of Benin. Their corrections and suggestions were incorporated in the final draft of the instrument.

The reliability of the instrument was determined through test-retest method. The test was administered twice with a period of two weeks to 20 respondents who employers of labour in automobile industry in Delta State. The results from the two administrations was subjected to Pearson's Product Moment Correlation statistics and it yielded an r- value of 0 .076.

The instrument was administered by the researcher with the help of two research assistants who were properly briefed on how to administer the questionnaire and retrieved the completed copies of the questionnaire from the respondents. The exercise lasted for two weeks and 121 copies of questionnaire were returned indicating 100% return rate.

The data generated from the administration of the questionnaires were analyzed using Mean to answer the research questions and z-test was used to test the hypothesis at 0.05 level of significance. The decision rule was based on 2.50 criterion mean such that calculated mean value of any item greater than or equal to 2.50 was regarded as require while mean value less than 2.50 was considered as Some times require, while for research question two, calculated mean value equals or greater than 2.50 for any item was regarded as High Influence and whereas, calculated value less 2.50 was considered little Influence rated. On the basis of the hypothesis, the probability value (P) was used. If p-value was less than 0.05, the null hypothesis was rejected, whereas if the p-value was equal to or greater than 0.05, the null hypothesis was retained.

Presentation of Results

Results for the data analyzed for the study are presented in Tables 1 to 3 below

Research Question 1

What are the skills needed by automobile technology graduates for diagnosing auto-electrical faults in motor vehicles in Edo State?

Table 1: Mean and Standard Deviation of Skills Required by Automobile Technology Graduates.

S/N	Item Statement	Mean ($\bar{X}$)	SD	Remarks
1	Diagnosing and trouble- shooting skill	2.94	0.99	Required
2	Initial battery test	2.82	0.97	Required
3	Wiring diagram interpretation skill	2.92	0.96	Required
4	Repair and installation skill	3.10	1.07	Required
5	Measuring voltage of cells on open circuit using battery testing equipment e.g. high rate discharge tester	3.29	1.84	Required
6	Measuring voltage of cells under load using battery testing equipment e.g. high rate discharge tester	2.96	1.18	Required
7	Determining the serviceability of components e.g. armature on the growler, starter motor	3.03	1.13	Required
8	Electrical and electronic system knowledge skill	2.90	1.14	Required
9	Component knowledge skill	2.99	1.18	Required
10	Safety awareness skill	3.04	1.24	Required
11	Attention to detail	3.12	1.23	Required
12	Faults tracing and rectification in windscreen wiper circuit	2.94	0.88	Required
13	Time management skill	2.85	0.92	Required
14	Faults tracing and rectification in petrol pump circuit	3.11	0.99	Required
15	Hand – Eye coordination skill	3.00	0.91	Required
16	Customer service skill	3.11	0.88	Required
17	Communication skill	3.01	1.01	Required
18	Diagnosing of common coil ignition system faults	2.97	0.89	Required
19	Ability to work independently and as a team skill	3.13	0.88	Required
	Total	**3.01**	**1.18**	**Required**

Source: Field Study, 2023

Results shown in Table1 revealed that mean values of the respondents ranged from 2.83 to 3.29 which are greater than the criterion mean of 2.50. The Table shows that all the 19 skills listed were rated as required. The result shows that employers of labour agree that all the listed skills are require by automobile technology graduates for diagnosing auto-electrical faults in automobile vehicles in Edo State.

Research Question 2

What are the factors influencing acquisition of skills needed by automobile technology graduates for diagnosing auto-electrical faults in motor vehicles in Edo State?

Table 2: Mean and Standard Deviation of Factors Influencing Acquisition of Skills Needed by Automobile Graduates.

S/N	Item Statements	Mean ($\bar{X}$)	SD	Remarks
1	Mismatch between university automobile technology curriculum content and workplace needs	3.03	1.13	Moderate influence

2	Difference between learning environment (school workshop) and workplace environment	3.04	1.24	Moderate influence
3	Use of outdated and obsolete equipment for training	3.15	0.92	Moderate influence
4	Use of teachers that have no practical skills	3.11	0.88	Moderate influence
5	Absence or inadequacy of teaching and learning materials	3.07	0.89	Moderate influence
	Total	**3.08**	**1.01**	**Moderate influence**

Source: Field Study, 2023

Results shown in Table 2 revealed that mean values of the respondents ranged from 3.03 to 3.15. The table shows that every factor listed moderately influence the acquisition of skills. The result shows that employers of labour agreed that the listed factors influenced the acquisition of skills required by automobile technology graduates for diagnosing auto-electrical faults in motor vehicles in Edo State.

Hypothesis

There is no significant difference between the opinion of male and female employers on the skills needed by automobile graduates for diagnosing auto-electrical faults in motor vehicles in Edo State.

Table 3: t-test results of the Difference between Male and Female Employers Opinions on Skills Needed by Automobile Technology Graduates

Gender	N	Mean	SD	t-value	df	p-value	Remark
Male	85	104.36	10.6	-0.253	119	0.801	Retained
Female	36	105.05	10.65				

Source: Field Study, 2023

The data in table 3 revealed that at df of 119, the p-value was 0.801 and the t-value was 0.235. It means that the p-value was greater than the t-value. It therefore depicts that the null hypothesis which starts that there is no significant difference between the opinion of male and female employers on the skills required by automobile graduates for diagnosing auto-electrical faults in motor vehicles in Edo State is retained.

Discussion of Findings

The result of the analysis of research question one as shown in Table 1 revealed that the employers of labour in the automobile industry agreed that all the skills listed are needed by automobile graduates in Edo State. The opinion of Ezeji and Okorie (2018) that Nigeria's social and economic problems will be drastically reduced if people are given adequate vocational training in skills, raw materials, machineries and equipment is in consonance with the findings of this study. This finding is in agreement with Jimoh (2017), who observed that technical education graduates of Automobile Technology programmes need practical skills for carrying out maintenance work to the expectations and satisfaction of their employers.

The result of the analysis of research question two as shown in Table 2 revealed that the listed factors influenced the acquisition of skills needed by automobile technology graduates for diagnosing of auto-electrical faults in motor vehicles in Edo State as agreed by employers of labour. This is in agreement with the findings of Atsumbe (2020) who attributed the trend of unemployment and under-employment to the mismatch between skills demanded in the workplace and those provided by the schools. The finding is also in agreement with one of the principles of vocational and technical education that the only reliable source of content for specific training in an occupation is the experience of the

masters of that occupation. Also, the environment of training should be a replica of the environment of work (Prosser in Init, 2019).

The result of the t-test analysis as presented in Table 3 shows that male and female employers of labour did not differ significantly in their opinion of skills needed by automobile technology graduates for diagnosing auto-electrical faults in motor vehicles in Edo State. Hence, the null hypothesis was retained. The opinion of Denton (2016) that the male and female employers of labour in the automobile industry have been known to be "male-dominant" for ages, where females comprise of 15% and males 85%, at all levels in the automobile industry largely due to their skill levels is at variance with this study.

Conclusion

Based on the findings of the study, it was concluded that the skills needed by automobile technology graduates for diagnosing auto-electrical faults in motor vehicles in Edo State as agreed by employers of labour are; diagnosing of common battery faults and their symptoms, conducting initial battery charge and recharge, measuring specific gravity of electrolyte using hydrometer, and measuring voltage of cells on open circuits using battery testing equipment amongst others. While the factors that influence these skills acquisition are mismatch between university automobile technology curriculum content and workplace needs, and the use of outdated and obsolete equipment in training amongst others.

Recommendations

Based on the findings of this study, the following recommendations were made:

1. Efforts should be made by stakeholders in the automobile industry to make automobile students to acquire skills for diagnosing auto-electrical faults in motor vehicles.
2. Stake holders in the automobile industry should ensure they checkmate those factors that could influence skill acquisition by automobile students in Edo State negatively.

References

Atsumbe, B. N. (2020). Basic academic, practical and affective skills to be emphasized in the curriculum: *Journal of Nigerian Association of Teachers of Technology*, 1(4), 119-126

Almaleh, A. (2019). *A framework to bridge the gap between acquired university curriculum and required market skills*: Faculty of Computing and Information Technology, King Abdulaziz University, 21589 Jeddah, Saudi Arabia.

Daluba, N. E. & Audu, T. A. (2016). Comparing the academic performance of sandwich and regular students in science, technology and mathematics education (STEM): implications for standards. In J. B, Omonu, T. A. Audu, P. P. Agashi (Eds): *sandwich / Part-Time Programme and Science, Technology and Mathematics Education in Nigeria (47-52).*
Sam Artrade Publisher. Anyigba.

Dennis, D (2022). Enhancing organizational effectiveness: Addressing inhibitors and eablers of continuous improvement in envisioning practice – implementing change. Australian Academic Press: Brisbane.

Denton, T. (2017). *Advanced automotive fault diagnosis: Automobile technology*: Vehicle maintenance and repair (4th ed.). Routledge.

Ezeji, S. C. O. A., & Okorie, J. U (2018). *Elements of guidance, vocational and career education.* Summer Education Publishers (Nig) Ltd: Onitsha.

Gabari, A. U. (2018). *Utilization of e –learning facilities on the teaching and learning of business education courses in colleges of education in Delta State.* Unpublished M.Ed thesis, Department of Vocational and Technical Education, University of Benin.

Init, M. M. (2019). *An appraisal of job performance of technical college motor vehicle mechanic graduates in Bauchi and Gombe States.* Unpublished M.Tech thesis, Department of Vocational and Technology Education, Abubakar Tafawa Balewa University, Bauchi.

Jimoh, J. A. (2017). *Auto mechanics skills needed by technical college students for self-employment*. Unpublished B.Sc thesis submitted to the Departmet of Vocational Teacher Education, University of Nigeria, Nsukka.

Kitainge, K. M. (2015). *Some significant research problems relating to teaching and learning, in learning in technology education: challeges for the 21st century*. Griffith University Press: Brisbane.

Kigwilu, P. C. (2017). *Resource Utilization and Curriculum Implementation in Community Colleges in Kenya*. Kenya School of Education, University of Nairobi, Kenya.

Marcu, O., & Pop, A.-M. (2024). *A modern diagnostic approach for automobile systems condition monitoring*. Journal of Physics: Conference Series, 2670(1), 012033. https://doi.org/10.1088/1742-6596/2670/1/012033

National Bureau of Statistics. (NBS) (2022). Unemployment rate in Nigeria. Retrieved from www.nbs.gov.ng/unemployment-rate.

Niyitanga, T. (2021). *Factors affecting the use of practical work in teaching and learning physics*: Assessment of six secondary schools in Kigali city, Rwanda.

Osuala, E.C. (2018). *Foundation of vocational education*. Fulladu Publishing Company, Nsukka.

Poka. (2023, July 7). Reskilling frontline workers in the automotive industry. https://www.poka.io

Small Medium Scale Development Agency of Nigeria, (SMEDAN) (2023). Registered automobile industry employers. Ministry of Wealth Creation, Benin City, Edo State.

AUTOMOBILE TECHNOLOGY EDUCATION FOR SUSTAINABLE DEVELOPMENT: ADVOCACY AND EDUCATION

UKUMA SOLOMON, Ph.D
TECHNICAL EDUCATION DEPARTMENT
COLLEGE OF EDUCATION, KATSINA-ALA
BENUE STATE, NIGERIA
EMAIL: ukumasolomon@gmail.com
PHONE: 08066638515, 08054533244
AND
DEKE, NYITAR GABRIEL
TECHNICAL EDUCATION DEPARTMENT
COLLEGE OF EDUCATION, KATSINA-ALA
BENUE STATE, NIGERIA
EMAIL:dekeng138@gmail.com
PHONE: 08134595784

Abstract

The paper is on automobile technology education for sustainable development; Advocacy and Education. The paper critically examine advancing automobile technology education teaching and learning for students to acquire the culture of diagnosing, repairing, maintaining and researching or the high spirit of finding out what happens to the components inside the engine that the vehicle is moving or has stop without the driver stopping it. The paper identities and analyzes the gaps that exist between automobile technology education policies and actions that are not in line with global best practices. The paper revealed how automobile technology education programme can drive and improve Nigeria's economy for sustainable development. The paper draws conclusion with suggestions/recommendations on the urgent need for automobile technology education programmes in Nigerian institutions of learning should be made more attractive to the citizenry through adequate funding, easy accessibility to subsidized instructional materials such as electrical wiring diagrams, automotive diagrams, dead and live vehicles for teaching students practicals, overhead projectors, soft wares, engine diagnostic machines, oscilloscopes, gum, gaskets, injector and carburetor cleaners are highly needed in order to carryout effective and efficient teaching and learning in institutions of learning. Finally, the paper suggested that, both federal, states and local government should employ highly qualified automobile technology education lecturers and teachers, purchase standardized and globally used automotive training equipment machines, hand tools and offer automobile technology courses for effective teaching and learning of automobile technology education. Furthermore, automobile technology education courses should be established in all the universities, colleges of education, polytechnics and all vocational and technical education institutions in Nigeria.

Keywords: *Automobile Technology Education, Sustainable Development, Advocacy and Education.*

Introduction

The unemployment market keeps on growing every year. Graduates of our universities, colleges of education and polytechnics are finding it extremely difficult to secure jobs as they were not trained to be self-reliant. The automobile technology education

is therefore, needed to give the Nigerian youths a sense of belonging and as a prevention against juvenile and adult delinquency and crime. Nigeria seriously need automobile technology, engineers, technicians and scientists as it is stated in the NPE. Sustainable national development could be defined as the means of empowering the citizenry to overcome poverty, limit the incidence of social vices due to joblessness and promote a culture of peace, freedom and democracy in Nigeria so as to meet global challenges.

Vocational and technical education advocacy could be defined as the education or public awareness, acceptability and support to automobile technology programmes to cause or make the teaching and learning of automobile technology a success in well-established automobile technology programmes in vocational and technical education institutions of learning. Automobile technology education students today may identify or know all the systems of a vehicle but may not know their operational sequence and do not have technical know-how on how to diagnose, maintain and repair the vehicle. Practical application of automobile technology is what institutions of learning in Nigeria should set out to improve. Furthermore, the improvement of these would greatly de-emphasized theoretical works and consequently bring about functional automobile technology education graduates in our institutions of learning to day hardly secure immediate employment unlike in developed and developing countries.

Advancing Automobile Technology Education Teaching and Learning for Sustainable Development

The problem with Nigeria is that we lay much emphasis on theory than practical. This kind of learning will not make our automobile technology education students to have the culture of diagnosing, repairing, maintaining and researching or the high spirit of finding out what happens to the components inside the engine that the vehicle is not moving or has stop without the driver stopping it. There is need for adequate training facilities so as to make automobile technology education works as planned. Olayinka and Oyenuga (2011) were of the view that, the integration of the theoretical and practical contents of automobile technological development into the existing motor vehicle curriculum is important. If the system of these new brands of vehicles are not integrated into the programmes for training the automobile technology education students, the new trend may spell a doom for the transport sector.

There is need for an adequate training facilities so as to make automobile technology education programme works as planned. Although automobile technology programme has not been given adequate care as regard the standard for laboratories, machines, equipment, tools and the caliber of automobile technology lecturers or teachers in our institutions of learning. The products of the current automobile technology programme, without adequate training facilities and teachers/lecturers cannot claim to be properly grounded or educated since they will lack much of the automobile technology technical know-how or practical skills and techniques in them. It is expected that, as soon as the automobile technology student are taught theory aspect, they should also be next skillfully to practicals which involve ability to estimate cost of repairs, communicate well in English, read both electrical/electronics, automotive air-conditioning wiring diagrams and circuits and the ability to conduct research and be up to date on automotive issues in line with global standards or as it is being done in most of the industrialized scientifically technologically and advanced countries.

Automobile technology education is widely believed to be that aspect of the programme that has practical value on industrial, agricultural and transportation, use to the society. The non-availability of automotive services to cater for our needs in technological advancements have been the major obstacle in our move to technological independence. This is coupled with our ignorance on the need to revamp vocational and technical education which incorporate automobile technology education which incorporate automobile technology education programme in our institutions of learning. It is regrettable to note that, in a country where majority of the citizens are ignorant about vocational and technical education have more emphasis on liberal arts who do not add value to themselves and the society at large. Most Nigerian's therefore, feel revamping vocational and technical education is a waste of funds or finances, they have much more beliefs in metaphysics than in science and technology courses.

The attitudes towards the curriculum of the African institutions was confirmed by Fishel (1969) that, in 1962 United Nation Educational Scientific and Cultural Organization (UNESCO) sponsored a conference at Tananarive on the Development of Education in Africa. Although the final report of that meeting was all-encompassing, one of its recommendations is instrumental to this series of articles. The conference strongly advised African universities to formulate curricula that, would permit them to contribute more effectively to the development of their nations. In particular the conference recommended that, at least 60 percent of students at an African university should specialize in the sciences. 31 percent in the humanities and 9 percent in the social sciences. Fishel further reported that, the specialist have envisioned the university as an institution which most generate the high and middle-level technicians required for the drive to modernization. To furnish such specialists, these scholars have explicitly stressed the need for additional scientific and technical training in the transitional society. As such, African leaders, many of whom acceded to these recommendations and promised to accord greater recognition in science and technology in the curricula of the African university.

Worse still in this country is that, most parents want their children to have or obtain degrees without functional skills, instead of reading courses that are practically oriented. It is also unfortunate that, only a few institutions of learning both higher and post primary throughout the country can claim to have established automobile technology education courses. As this is the case, how can we achieve or stamp out unemployment in automobile technology subsector without adequate automobile technology education provisions? The benefits Nigeria could drive from a well-structured and functional automobile technology education programme as satisfying the naturally inquiring minds of students and widening their experience, promoting the development of both theory and practical skills and encouraging long-term skills as well as profitable use of leisure hours for acquisition of automobile technology education practical skills such as diagnosing, repairing, maintaining skills and techniques. Advancing automobile technology education teaching and learning could be achieved according to Ogwo and Oranu (2006) stated that, technical vocational education will effectively contribute to mass technological literacy of the populace. When Nigerians make technical relevance their primary consideration in the choice importable artefacts then other suitability criteria will be considered. Educating the populace on technical and economic implications of their activities is one essential aspect of vocational education that requires urgent attention by all and sundry.

Gaps between Automobile Technology Education Policies and Actions

Today, it is new found that even few automobile technology education students who have completed their programme in different institutions of learning are unable to estimate the problem of the vehicle, diagnose, and carry out repair works correctly. Ukuma (2021)

confirmed the above, when he stated that, automotive technicians are expected to diagnose, service and completely repair any problem on the vehicle.

This is in addition to the need to be computer literate, read both electrical and automotive air-conditioning wiring diagrams and ability to conduct research and be up to date on automotive issues in line with global best practices or standards. Ukuma explained further that, the automobile technology education curriculum used in our institutions of learning is deficient because of practical and theory activities are highly in sufficient for meaningful skills impartation and acquisition. Also equipment, machines, live and dead vehicles and hand tools for training in our institutions of learning seem not to meet the challenges of modern vehicles. Automobile technology education students lack skills in the repair and maintenance of layout of vehicle auto-electrical system, transmission system, suspension system, vehicle engine, braking system and electronic and electrical components.

Supporting the deficient of the automobile technology education curriculum as stated above, Nweke (2005) earlier stated that, our educational policies and programmes fail before ever they start. It is lack of concrete planning that brings uneasy ending of the policies and programmes. Automobile technology education programmes at various levels of educational sector encountered the difficulty of shortage of man-power (qualified teachers and lecturers) and the infrastructural facilities (school laboratories and automotive equipment, tools live and dead vehicles and machine). In a bid to meet the manpower need, Government may resort to the recruitment of automobile technology teachers or lecturers. Furthermore, there is less than enough of automobile technology education teachers or lecturers in existing institutions of learning and currently the position has not improved. The aim of our great country and the giant of Africa, Nigeria, is to become independent in automotive sector. But how do we achieve this when, the basic live and dead vehicles, equipment, machines, hand tools and automobile lecturers or teachers and infrastructural facilities are not available? The federal, states and local governments has an arduous task of combating all obstacles that hinder functional automobile technology education. If the automobile technology education programmes at various institutions becomes in operated then, we may not find our stand convenient to introduced new innovations from automotive industries to the classroom successfully. Therefore, Nigeria cannot reduce unemployment in the area of automotive industries to the classroom successfully.

Our automobile technology education curriculum, if anything, has been most irrelevant to our needs, because it emphasizes theoretical knowledge. Automobile technology if properly restructured in the areas of employing qualified teachers/lecturers, providing the necessary infrastructures would definitely help in pushing the country into rapid development. Automobile technology is also an education of self-reliance which is good for Nigeria as the giant of Africa.

Although, automobile technology education students who are determined, intelligent and have the abilities can still advance to higher studies while, those who graduates but have difficulties in various ways can set up their own automotive workshops, tire alignment workshops, vehicle spraying and body building workshops for a living. The current practice do not emphasis practical approach to automobile technology education, production and sustainable development. Most parents are ignorant and sad of the entire nonfunctional and unemployable educational system. There is every need for parents not to feel happy that their children or wards upon graduating from Nigerian institutions of learning not only read and write but cannot service, produce simple components such as nut, bolt, even a tool such as spanner maintain and diagnose a vehicle effectively. Therefore, it is sacrosanct for federal, states and local governments to construct workshops, install globally acceptable

used equipment, machines and tools for automobile technology students to develop their talents and abilities.

Therefore, the fault has been identified but the suitable and reliable solution is what stakeholders in automobile industry should gamble for.

Automobile Technology Education Programme to Drive Nigeria's Economy

The absence of effective automobile technology education in our educational systems is telling much on our economy which is declining. Our automobile technology education students continue to depend on road side mechanics to improve on their practical skills and techniques in diagnosing, repairing and maintenance of old and new models vehicles on Nigerian roads to day. If the automobile technology education programme is to work as planned, there is urgent need to provide the automotive programme with adequate and standard automotive equipment, machines, tools, reference materials, automotive journals, vehicle manuals of all kinds among other. According to Schwaller in Ogwo (2006) the automatable now has the world's largest manufacturing industry and it has strongly influenced the economic and social evolution of modern industrial societies. For example, the following industries owe their growth largely to the development of the automobile industry: petroleum refining, road construction/maintenance, motor vehicle manufacturing, replacement parts, manufacturing/distribution, automobile sales/servicing, passenger/goods transportation, insurance companies and support industries like plastics, rubber, steel, glass, electronics and fabrics, among others and it is estimated that, 30 million people around the world depend on the automotive industry for their jobs. Automobile technology education programme lie somewhere within the confines of leadership or management of institutions. It a pure reflection of misplacements of priorities and gross mal-management of nations resources. Similarly, Ogunlade (2005) opined that, through automobile technology education man had been able to conquer the land by automobiles, which had made life easier more comfortable and more meaningful.

It is worrisome that 63 years after political independence, Nigeria still much depend on other developed and developing nations of the world for our automotive parts both new and old vehicles among others. Ideally, much has to be done by government, stakeholders in the entire educational sector, national automotive council of Nigeria, automotive industries, national business and technical education board, Automotive teachers or lecturers, parents and students national universities commission, national commission for colleges of education (NCCE) in identifying the challenges facing automobile technology education programmes in institutions of learning. The automobile technology education programmes in various institutions of learning should be made more attractive to the citizenry through mass education and easy accessibility to subsidized teaching and learning materials.

Moreover, Onwumere (2005) reported that in the modern world, a nation that has no control over the transportation sector is in danger of losing her economy and trait of its culture. Onwumere reiterated that, transportation is a powerful weapon of war in international politics. Therefore, the federal government should give licenses to genuine companies who can engage in manufacturing of automotive activities that can create jobs for our unskilled graduates in Nigeria.

Nigeria need vehicle parts or components manufacturing companies distributed in all parts of the country and desire positive actions in automobile technology education programme in various level of educational sector. But the unfortunate thing is that, we cannot achieve any remarkable progress in insulation of deliberate appraisal of our past, re-charting positive courses of actions through adequate forecast and formulation of strategies, mobilizing our resources and subjecting our performance to adequate planning, control, co-

ordination and direction based on objectivity and not mere emotions or lip services on automobile technology education programmes in institutions of learning in Nigeria.

Automobile technology education programmes in institutions of learning, if accorded it rightful place, it would change the economy hence automobile technology programme is a veritable tool for accelerated national development.

Research in automobile technology education would reduce the total dependency syndrome on the area of automotive importation to a certain level and reinvigorate the economy and research finding in automobile technology education would improve the teaching and learning of automobile technology education in institutions of learning. Furthermore, it should be pointed out that, if Nigeria is to encourage local production of vehicles, automotive spare parts and other accessories, the volume of imported new and fairly used vehicles would be drastically reduced and the Nigerian economy would stratospherically improve. Nigeria need leaders who may recognized the place of automobile technology education in national development.

Conclusions

Automobile technology education programmes in Nigerian institutions of learning should be made more attractive to the citizenry through adequate funding, easy accessibility to subsidized instructional materials such as live and dead vehicles, machines/hand tools, gaskets, gums, engine oil, masking tapes, oil filters, injector and carburetor cleaner. The above instructional materials are consumable and non-consumable that are highly needed in order to carry out effective teaching and learning of automobile technology education in institutions of learning to drive Nigeria's economy for sustainable development.

Suggestions

This paper suggest/recommends that; government should employ qualified automobile technology education lecturers and teachers, standardized globally used automotive training equipment, machines and hand tools.

Automobile technology education courses should be established in all the universities, colleges of education, polytechnics, vocational and technical education institutions in Nigeria and government should intensify efforts towards motivating automobile technology teachers/lecturers so that they can well transfer the much needed technical and professional skills to automobile technology students.

References

Fishel, M. (1969). Attitudes towards the curriculum of the African University (part I).*West African Journal of Education*. Pages 12-15.

Ijagbone, I. (2011). Science and Technical Education, Key to national development. Daily Sun Tuesday, December 29, 2011. www.sunnewsonline.com

Nweke, A. O. C. (2005). Educational Policies and programmes fail before ever they start. Times International, Monday, December 9, 2005 pg. 5.

Ogunlade, Y. (2005). Utilizing Science and technology in solving man's problems. Technical education today vol. 3, No.1 and 2. ISSN 0705-4654 published by National Board for technical education plot 3 Bida Road Kaduna, Nigeria.

Ogwo, B. A. and Oranu, R. N. (2006). Methodology in formal and non-formal technical/vocational education. University of Nigeria Press Limited.

Ogwo, B. A. and Oranu, R. N. (2006). Methodology in formal and non-formal Technical/Vocational Education. University of Nigeria, Nsukka.

Ojir, U. K. (2016). Challenges of democratic governance in nigeria. (1) Saturday Sun, August 13, 2016. Page 55 Published by the Sun Publishing Limited, Ikeja, Lagos.

Olayinka, O. and Oyenuga, A. O. (2011). Integration of Automobile Technological Development into Nigeria College. Motor vehicle mechanics work curriculum: Retrieved from mhtml: fiter: //E:integration%200f%20automobile%20technological%20develoments%. 6/30/2011.

Onwumere, S. (2005). Times International Economy Monday, December 9, 2005 page 28.

Oshunkeye, S. (2016). The insecurity in security votes. Sunday Sun August 7, 2016 page 52.

Ukuma, S. (2021). Analysis of the Nigeria certificate in education programme in automobile technology curriculum in preparing students for employment in North-central Nigeria. Unpublished PhD Thesis department of Industrial Technical Education, University of Nigeria, Nsukka.

Ukuma, S. and Deke, N. G. (2010). Repositioning Nigerian Vocational Technical Education for sustainable National development. *Journal of Educational Innovation.* ISSN: 115-5283. Vol. 3, No.2 July, 2010, pages 114-120.

Ukuma, S., Ipusu, K. A., Attah, M. E., and Ochedikwu, J. O. (2013). Technical and Vocational Education for achieving Millennium Development Goals (MDGs) in Nigeria. In Nigeria and the challenges of transformation. Edited by Barnes Anger and Agbyoko-Agu Gideons. Makurdi Vast Publishers.

Wike, N. (2016). The Nigerian Economy. Daily Sun Thursday August 16, 2016. Page 24.

COMPETENCY IMPROVEMENT NEEDS OF CRAFTSMEN IN MOTOR VEHICLE MECHANIC WORK FOR ENHANCING EMPLOY-ABILITY IN AUTOMOBILE INDUSTRIES: AN EVIDENCE FROM NIGERIA

Mukaila Abiodun Yisa
Department of Industrial Technical Education
Tai Solarin University of Education
yisama@tasued edu.ng

Abstract

The study was carried out to determine competency improvement needs of craftsmen in motor vehicle mechanic work for enhancing employ-ability. Three research questions guided the study. A descriptive survey design was employed for the study. The study was carried out in Ogun State, Nigeria. The population for the study was 121 craftsmen of motor vehicle mechanic from industries in the study area. Structured questionnaire item was used for data collection. Cronbach alpha reliability method was used to determine internal consistency of the questionnaire items and reliability coefficient of 0.84 was obtained. One hundred and twenty one copies of the instrument were administered on the subjects at different locations with support of three research assistant, with a week interval for the collection of administered copies. One hundred and fifteen were collected back which represented 95.04 percent return rate. The data collected were analyzed with weighted mean and improvement needed index (INI). The findings of the study revealed that MVMP craftsmen need skill improvement for competency in motor vehicle mechanic practice. It was recommended that all the identified competencies in motor vehicle mechanic work should be packaged and integrated into the curriculum of motor vehicle mechanic practice in technical colleges.

Keywords: Competency, Employ-ability, Improvement. Craftsmen

1. Introduction

The essence of schooling or attending school is to acquire knowledge, skills and attitudes for employment and national building. The combination of knowledge, skills and attitudes is called competence. Competence is the ability to do something successfully or efficiently. [1] defined competencies as sets of behaviors that are instrumental in the delivery of desired results. [2] also stated that competency is a collection of behaviors and kills which people are expected to show in their organization. Skills are learned, white competencies are inherent qualities an individual possesses; which is the combination of skills, knowledge and ability. For the purpose of clarity. [3] defined skill as the ability to perform expertly well, facility in performance with dexterity and tact through what one has learnt and practiced in training. Skill is the ability to make a purposeful movement that is necessary to complete or master a particular task in a given job [4]. Skill therefore is the ability and capability acquired through deliberate, systematic, and constant effort to smoothly and adaptive to carryout multifaceted activities or job functions involving the maintenance of split air-conditioner. Competency therefore is the combination of skills, knowledge and attitudes to be possessed by motor vehicle mechanic practice craftsmen for effective maintenance of all kinds of automobiles.

Motor vehicle mechanic practice (MVMP) is one of the trades offered in technical colleges in Nigeria MVMP is one of the vocational trades in which students are to acquire knowledge, skills and attitudes to work efficiently. According to [5], MVMP is designed to produce competent auto mechanics craftsmen for Nigeria technological and industrial development. Craftsmen in this study are individuals who studied trades in technical

colleges and graduated. They are sometimes called skilled person because of the nature of the training they received. According to National Board for Technical Education [6] auto mechanics craftsmen are expected to test, diagnose, service and completely repair any fault on the motor vehicle to the manufacturers specification.

In the report of [7], the aim of motor vehicle mechanic practice is to give training and impart the necessary skills leading to the production of craftsmen, technicians and other skilled personnel who will be enterprising and self-reliant. Report of [8] specified that components of MVMP are arranged in modules and the components include: engine maintenance, suspension, steering and braking system, auto electricity, transmission reconditioning work. major engine repair works and service station mechanic. Students and craftsmen of motor vehicle mechanic practice are expected to acquire skills in these modules under the guidelines of their teachers.

Technical colleges are post primary schools where students learn skills in various occupations. According to [9], the technical colleges are charged with the production of craftsmen and technicians. [10] said that technical colleges are designed to prepare individuals to acquire practical skills, basic scientific knowledge and attitudes required as craftsmen and technicians at sub-professional levels. [11] said they are regarded as the principal vocational institutions in Nigeria that give full vocational training intended to prepare students for entry into various occupations as operatives or artisans and craftsmen. Graduates who underwent training in motor vehicle mechanic practice are known as craftsmen and they are expected to have possessed competencies for success in engine maintenance, suspension, steering and braking system, auto electricity, transmission reconditioning work, major engine repair works and service station mechanic. Observations reveal that these craftsmen have little or no skills in MVMP. Most of them remain jobless in the society and they neither set up their workshops nor employed by automobile industries in the State. Most of these craftsmen could not secure appointment in standard automobile maintenance industries. Moreover, [12] stated that half-baked auto craftsmen in the society often cause more damages to vehicles when they are contracted to service them. The author further explained that many serviced vehicles by these craftsmen have sent many people to their early deaths due to inadequate services given to these vehicles. In order for these craftsmen to be employed or perform their functions in society, they need improvement in their competencies.

Improvement is the process of making something better than before. Improvement according to [13] is ability or condition for becoming better than before. In this study, improvement is the process of helping graduates in the area of study acquire to a higher proficiency level, work skills in motor vehicle mechanic practice for greater efficiency. For work to be done requires energy and skills and one need competencies for sustainable employment. Employment according to [3] means working for one's self or an employer. To be employed, an individual need to be highly skill in a trade. To know where craftsmen of motor vehicle mechanic practice need improvement, their competencies are necessary to be assessed. It will reveal the level of knowledge, skills and attitudes possessed and the areas in which improvement is needed based on their performance gap. The purpose of this study therefore is to determine the competencies improvement needs of craftsmen' in motor vehicle mechanic practice for enhancing employ-ability. Specifically, the study sought to determine

1. Work skills improvement need of graduates in engine maintenance
2. Work skills improvement need of graduates in steering and braking system
3. Work skills improvement need of graduates in auto electricity

2. Research Questions

The following research questions guided the study

1. What are the work skills improvement needs of graduates in engine maintenance?
2. What are the work skills improvement needs of graduates in steering and braking system? 2
3. What are the work skills improvement needs of graduates in auto electricity?

3. Methodology

A descriptive survey design was adopted for the study. This design was suitable for the study since it intends to obtain data from the craftsmen of motor vehicle mechanic practice from technical colleges in Ogun State of Nigeria. The study was carried out in Ogun State of Nigeria. The population for the study was 121 craftsmen of motor vehicle mechanics practice. There was no sample for this study because of small size of the population. The instrument for data collection was a structured questionnaire that contained 43 competency items and the questionnaire were divided into two categories of needed and performance. The needed category has a 4-point response scale of Highly Needed, Averagely Needed, Slightly Needed and Not Needed; while the performance category also has 4-point response scale of High Performance, Average Performance. Low Performance and No Performance with a corresponding value of 4, 3, 2 and 1 for the two groups of scales respectively. The instrument was validated by three experts in the Department of Industrial Technical Education, University of Nigeria, Nsukka. Cronbach alpha reliability method was employed to determine the internal consistency of the questionnaire items with a reliability coefficient of 0.84. One hundred and twenty one copies of the questionnaire were administered by the researchers and three research assistants on the craftsmen in the study area with a week interval for the completion of the questionnaire. One hundred and fifteen copies of the questionnaire were retrieved which represented 95.04 percent return rate. Weighted Mean and Improvement Needed Index (INI) were used in analyzing data collected in order to answer the research questions. The improvement needs was determined as follows:

i. the mean (Xn) of the needed category was determined for each item.
ii. the mean (Xp) of the performance category was also determined for each item.
iii. the performance gap (PG) was therefore determined by finding the difference between Xn and Xp for each item; that is PG=Xn-Xp

(a). Where the value of PG is positive (+), it means improvement is needed because, the level at which the craftsmen performed in motor vehicle mechanic practice is lower than what is needed.
(b). Where PG is negative (-), it means improvement is not needed because, the craftsmen of motor vehicle mechanic practice performed the operations of the item is more than what is required.
(c). Where PG value is zero (0), it means improvement is also not needed because; the level at which the craftsmen were performed in motor vehicle mechanic practice items is equal to the level that was needed.
Each question item was assigned a four point response scale of strongly needed, needed, slightly needed and not needed with values of 4, 3, 2 and 1.

4. Data Analysis and Results

The results for the study were obtained from the research questions answered through data collected and analyzed.

Table 1: Performance Gap Analysis (PGA) of the Mean Ratings of Motor Vehicle Mechanic Work Craftsmen on Competency Improvement Needs in Engine Maintenance

S/N	Item statement	Xn	Xp	PG=Xn-Xp	Remarks
1	Locate faults in the automobile using appropriate tools and equipment	3.80	2.00	1.81	IN
2	Remove faulty units from the automobile for servicing	3.60	1.78	1.82	IN
3	Use appropriate tools and equipment for a particular operation on the vehicle	3.57	3.28	0.29	IN
4	Dismantle fault unit correctly	3.62	3.55	0.07	IN
5	Identify bad component		3.43	2.35	108
6	Carry out preventive and corrective maintenance correctly	2.82	2.66	0.16	IN
7	Conduct engine performance test and determine needed repair	3.65	1.91	1.74	IN
8	Inspect, repair and replace electronic ignition components	3.78	2.63	1.15	IN
9	Connect types of protective device correctly	3.64	2.61	1.03	IN
10	Conduct engine performance test using engine 3.52 analyzer and determine needed repair	2.01	1.51	IN	
11	Diagnose emission control system and determine needed repair	3.76	2.06	1.70	IN
12	Perform on board computer diagnosis	3.75	1.60	2.15	IN
13	Perform oil and lubrication service on normally aspirated and turbo charged engines	3.69	1.99	1.70	IN
14	Servicing carburetors correctly	3.70	2.00	1.70	IN
15	Replace faulty alternator, fuel pump and plugs correctly	3.65	2.03	1.62	IN

Table I revealed that the performance gaps of 15 competency items are positive and ranged from 0.07 to 2.18 This indicated that the graduates need improvement in 15 competency items of engine maintenance. In general, the result revealed that craftsmen of MVMP from technical colleges need improvement in competency items for engine maintenance for employment.

Table 2: Performance Gap Analysis (PGA) of the Mean Ratings of Motor Vehicle Mechanic Practice Craftsmen on Competency Improvement Needs in Steering and Braking System

S/No	Item statements	Xn	Xp	PG= Xn- Xp	Remarks
1	Identify faults in brake system	3.56	2.00	1.56	IN
2	Remove bad brake pad from the drum.	3.67	2.11	1.56	IN
3	Carry out preventive maintenance in both steering and braking systems	3.61	2.04	1.57	IN
4	Remove power steering from the main unit	3.20	1.98	1.22	IN
5	Servicing automatic braking system correctly	2.78	1.10	1.68	IN
6	Select appropriate tools and equipment for the maintenance of power steering and automatic	3.03	1.38	1.65	IN

	braking system.				
7	Replace faulty or bad braking system with new one	3.54	1.91	1.63	IN
8	Check operation of anti-lock braking system, adjust and repair according to manufacturer's specifications.	2.99	2.00	0.99	IN
9	Operate and maintain all wheel steering system	3.05	2.01	1.04	IN
10	Carry out all kinds of mechanical test on steering and braking system	3.56	1.99	1.57	IN
11	Assemble repair or maintained steering system correctly	3.67	1.59	2.08	IN
12	Test repaired braking system for functionality	3.45	2.50	0.95	IN
13	Reinstall maintained or repaired power steering of modern vehicle.	2.60	1.69	0.91	IN

Table 2 revealed that the performance gaps of all the sixteen (13) competency items ranged from 0.91 to 2.08. All the performance gap values are positive indicating that the craftsmen need improvement in competency items for steering and braking system

Table 3: Performance Gap Analysis (PGA) of the Mean Ratings of Motor Vehicle Mechanic Practice Craftsmen on Competency Improvement needs in Auto Electricity

S/No	Item Statements	Xn	Xp	PG= Xn-Xp	Remarks
1	Identify faults in battery	2.99	1.56	1.43	IN
2	Conduct simple tests on battery for functionality	3.01	1.89	1.12	IN
3.	Identify bad or malfunctioned relay	3.53	3.02	0.51	IN
4	Detect burnt bulbs with appropriate instrument	2.59	1.70	0.89	IN
5	Check the protective devices on the vehicle for functionality	3.39	2.00	1.39	IN
6	Use testing lamp to detect open or short circuits in motor vehicle	2.98	1.89	1.09	IN
7	Replace faulty cells in the battery	2.90	2.01	0.89	IN
8	Connect two or more battery correctly in series	3.05	2.56	0.49	IN
9	Connect two or more battery correctly in parallel	3.53	2.38	1.15	IN
10	Connect battery in series and parallel	3.21	2.45	0.76	IN
11	Connect electrical components correctly to the motor vehicle	2.98	2.31	0.67	IN
12	Use ohmmeter to test fuses for functionality in the vehicle	2.98	2.51	0.47	IN
13	Rewiring of motor vehicle	3.56	2.78	0.28	IN
14	Tracing electrical faults in a vehicle	3.01	2.25	0.76	IN
15	Apply voltmeter for measuring voltage in the battery	3.21	057	0.64	IN

Table 3 revealed that the performance gaps of all the fifteen (15) competency items ranged from 0.28 to 1.43. All the performance gap values are positive indicating that the craftsmen need improvement in competency items for auto electricity.

5. Discussion of findings

The results of this study revealed that the craftsmen of motor vehicle mechanics work from technical colleges need improvement or training in engine maintenance, steering and braking system and auto electricity in order to be employed in automobile industries. The above results agreed with the findings of [14] who conducted a study on electrical installation and maintenance work skills needed by technical college graduates to enhance their employment in Ondo state where he found out that graduates require various work skills in domestic and industrial installation, cable joint, battery charging and electrical machine winding for employment after graduation. The findings of this study also in line with findings of [9] who carried out a study on safety practice skills needed by electrical electronic students of technical colleges in Ekiti State. The author found out that students of electrical/electronic need safety practice skills in using hand tools, operating power tools, operating electric machines, working electrical workshops and using instructional manuals or guide. The findings of the authors cited above help to validate the findings of this study.

6. Conclusion

Based on the result of the study, craftsmen of MVMP needed improvement in competency items in order to maintain, service and repair all kinds of automobiles in Ogun State. It is therefore recommended that all the identified competency items in engine maintenance, steering and braking system and auto electricity should be integrated into the curriculum of motor vehicle mechanic work of technical colleges for training of students.

References

UNICEF, (2019), UNICEF Competency Definitions.www.unicef.com

Rankin, N (2002) Raising performance through people: the ninth competency survey. Competency and Emotional Intelligence, January, pp 2-21.

Onoh B.C.E.C (2013). Fundamental of entrepreneurship studies. Enugu; Cheston Agency Press Ltd.

Mbah, C.O. & Umurhurhu, B. E. (2016). Improving the teaching-learning of computer aided drafting and designing (CADD) for effective skill development in Nigeria tertiary institutions, International Technology Research Journal (INTERJ) 4 (1)24-29.

Olayinka, O. (2009). Integration of Automobile Technological Development into the Technical College Motor Vehicle Mechanics Work Curriculum. An Unpublished M.Ed Project Submitted to the Department of Vocational Teacher Education, University of Nigeria. Nsukka

National Board for Technical Education (2001). Revised national Technical Certificate and Revised Advance National Technical Certificate Programmes for Motor Vehicle Mechanics Work Trade Curriculum and Course Specification. Kaduna: NBTE

National Board for Technical Education (2004). Curriculum for Technical Colleges. Kaduna: NBTE Press

Federal Government of Nigeria (2004). National Policy on Education. Lagos: NERDC Press.

Bakare, J. (2006). Safety Practice Skills needed by electrical electronic students of technical colleges in Ekiti State. An Unpublished PGDTE Project Submitted to the Department of Vocational Teacher Education, University of Nigeria, Nsukka

Akpan, A. C. (2003). The Quality of Training received in Electricity and Electronics Programme by Technical College Graduates in Akwa Ibom State. An Unpublished M.Ed Thesis. Department of Vocational Teacher Education, University of Nigeria, Nsukka.

Okoro, O.M. (2006). Principles and Methods in Vocational and Technical Education. Enugu: University Trust Publishers.

Jika, O.F. (2010). Effect of Guided Discovery Method of Instruction on the students' Performance in Auto Mechanics in Technical Colleges in Benue State. An Unpublished M.Ed Project Submitted to the Department of Vocational Teacher Education, University of Nigeria, Nsukka

Olaitan, S.O., Amusa, T.A. & Asouzo, A.I. (2010). Competency Improvement Needs of Instructors for Effective Teaching of Fish Preservation and Marketing to Students in Schools of Agriculture in Niger Delta States. Nigeria. A paper presented at the institute of education conference in 2010

Akinduro,l. R. (2006) Electrical Installation and Maintenance Work Skills Needed by Technical College Graduates to enhance their Employment in Ondo state An Unpublished M.Ed Project Submitted to the Department of Vocational Teacher Education, University of Nigeria, Nsukka.

SUB-THEME 7
CONTENT DEVELOPMENT TECHNOLOGY

PROMOTING INDIGENOUS KNOWLEDGE IN EDUCATION, SCIENCE AND TECHNOLOGY IN TERTIARY INSTITUTIONS

Robert O. Okwori CLN[1] & Elizabeth A.Okwori[2]
[1]Department of Industrial and Technology Education
[2]University Staff School
Federal University of Technology
Minna
Niger State, Nigeria

Abstract

The paper explained the meaning of indigenous knowledge (IK) as the understanding, skills and philosophies developed by people in a community based on histories and experiences by interacting with their environments. The importance of indigenous knowledge to the society was explained. The relevance of indigenous knowledge to education, science and technology was thoroughly discussed. The sources of indigenous knowledge, forms of knowledge, methods of preserving indigenous knowledge (IK) materials and characteristic of indigenous knowledge were discussed. The ways of promoting indigenous knowledge was discussed and some of them include providing enabling environment for practicing indigenous knowledge acquired or learnt, patent the products of IK, using print and local languages, using school administrators, use of traditional instructional methods in teaching and creating website on Ik in various areas of knowledge. Recommendations were made and it includes the following: Indigenous knowledge should be promoted in tertiary institutions to enhance more discoveries in education, science, technology and other disciplines, government should encourage utilizing indigenous knowledge in our society as many communities' survival relies on it. For instance, farming, developing their technologies, treating of illness using herbs or plants etc. and indigenous knowledge should be preserved using various methods for future use.
Keywords: Indigenous knowledge, Promoting, Education, Science, Technology

Introduction

Indigenous knowledge (IK) refers to the understanding, skills and philosophies developed by people in a community based on histories and experiences by interacting with their environments. According to Daniel(2022), indigenous knowledge is the traditional knowledge or traditional ecological knowledge which is the body of observations, oral and written knowledge, innovations, practices and beliefs that promote sustainability and responsible stewardship of cultural and natural resources through relationship between humans and their landscapes. Indigenous knowledge cannot be separated from people. It applies to phenomena across biological, physical, social, cultural and spiritual system. People developed their knowledge system and continue to do so through direct contact with the environment. It is through extensive observation, lessons and skills. Indigenous knowledge is also means traditional knowledge. Knowledge is the awareness and understanding of fact, truths or information gained in form of experience or learning. It could be through awareness, consciousness or learning. Knowledge also refers to information and understanding gained through learning or experience which passed on from generation to generation. It is important to note that there are two types of knowledge and these are explicit and implicit or tacit knowledge. Explicit knowledge can be called documented knowledge. Explicit knowledge is disseminated through documents, electronic forms and manuals. It can be shared, communicated and transferred in a coded form. Tacit knowledge is the knowledge which is

difficult to put in words, expressed through action based skills. Tacit knowledge is rooted in action.

Popp (2018) explained indigenous knowledge as traditional ecological knowledge (TEK). It is the cumulative body of knowledge associated with ecological relationships which are handed down through generations by indigenous people. Indigenous people with their personal experience combined have vast knowledge about the environment and ecological relationships. This knowledge contributes substantially to the development of science, education and technology. Indigenous Knowledge, traditional knowledge, folk knowledge and local knowledge are generally referred to as knowledge system. It is embedded in the cultural traditions of people in a region or communities. According to world intellectual property and the United Nations, traditional knowledge and cultural expressions are both types of indigenous knowledge. Traditional knowledge includes types of knowledge about traditional technologies of substance such as tools or agriculture, midwifery, ecological knowledge, traditional medicine etc. This type of knowledge is very essential for substance and for surviving. It is based on accumulation of empirical observation and interaction with the environment (Wikipedia). According to Etre in Popp (2018) explained that indigenous knowledge is known as traditional ecological knowledge and it is the cumulative body of knowledge associated with ecological relationships which is handed down through generations to generation by people in a community and it cannot be taken for granted as it has a lot of importance to the society. Similarly,indigenous knowledge is the cultural expression by people.

Li and Karakowsky in Udens (2017) explained culture as a system of knowledge shared by large group of people. Culture is a cultivated behaviour learned by people. It is an accumulated experience socially transmitted and it is symbolic to the people in a particular ethnic group. These symbols include group's skills, knowledge, attitudes, values and motives. The symbols are learned and perpetuated in a society through its instruction. In the same vain, culture is about people's total way of life. This refers to the way people live, worship, build, farm, develop their technologies etc (Udensi, 2017). Culture cannot be separated from indigenous knowledge and the importance of indigenous knowledge to the society cannot be over emphasized.

The importance of indigenous knowledge

The way people survive depends on their knowledge about the environment. People survive in a community based on the type of farming system adopted. Many plant species including crops are cultivated and enjoyed across the globe. Some of the crops include corn, squash, beans, potatoes, onion, peppers and so on (Popp, 2018). Another importance of indigenous knowledge are: increasing self-sufficiency and determination which give rise to many scientific discovery, it increases cultural pride and motivation to solve local problems with local resources. People use indigenous knowledge to provide valuable input about their environment and also how to manage the local resources effectively.

The relevance of indigenous knowledge to education, science and technology

Indigenous knowledge has contributed a lot to the development of education, science and technology in the society. The contributions of indigenous knowledge to the growth of education science and technology is enormous.

Science - Science is the systematic study of the structure and behaviour of the physical and natural world through observation, experimentation, and the testing of theories against the evidence obtained (www.britannical.com> science). There is an adage that says ''science is the mother of all invention''. Indigenous science incorporates traditional knowledge while non-indigenous scientific approaches are recognized in western science. The value of integrating indigenous science with western science can't be over emphasized. Both western

and indigenous science approaches have their strengths and can complement one another greatly. Indigenous knowledge about the medicinal properties of plants has been instrumental in pharmacological development. People in various communities use plants to treat different illness and the scientists study the compound of such a plant and develop vaccine or drug. Life-threatening scurvy was treated in North America through conifer-needle tonics that were rich in vitamin C. The active ingredient in the pain reliever Asprin was first discovered by indigenous people who utilized the bark of the willow tree. Africa has a rich floral diversity which provides materials for the treatment of fevers and malaria and thus should afford the next generation of drug or templates necessary for their synthesis (Bashir in Jigam, 2016). Natural products accounts for two-thirds of all drugs introduced in the past three decade (Newman & Craig in Jigam, 2016). The connection between medicinal plants and antimalarial drugs was dated back to 1820 when quinine was first isolated from the bark of CinChina SPP (Abaye et.al in Jigam 2016). This means indigenous knowledge was used to develop modern medicine or drug (Nicholas, White, Mcgregor & Smith, 2017). Different crops are cultivated and enjoyed across the globe through indigenous knowledge. Indigenous knowledge relating to farm practice has brought about different varieties of crop with efforts of agricultural scientists. Now, food beverages and other items are preserved using refrigerators. This idea was developed from the way food beverages and other items were preserved in communities in the ancient period. Plate 1 and 2 presented below show how indigenous knowledge has contributed to the development of agriculture and other aspects of science.



Plate1: Corn, tomatoes, squash etc available using Indigenous knowledge and



Plate 2: Science practical conducted based on experience materials obtained from people in the community

Source: Shutterstock in Popp (2018)

Technology

Technology is the application of scientific knowledge for practical purposes whether at home or industry. Technology is the application of scientific knowledge to achieve practical ends. We are surrounded by technology in our environment and most people wouldn't know how to operate or live without it (www.britannical.com> technology). Technological innovations such as canoe, bicycle, motorcycle, vehicle, aero plane has aid transportation. Indigenous knowledge has contributed to modern technology. Etre in Popp (2018) explained that indigenous knowledge has long added value to modern technology. She disclosed that preservation techniques were adopted to protect a canoe known as Swan Lake Canoe. Ohize

(2016) revealed that there had been form of technology in Nigeria before the advent of modern technology. In the past, people applied their knowledge to solve their problems and challenges. All forms of practical activities for meeting their needs was inform of technology application. Such technology application includes pottery making, weaving, farming, leather work, carpentry and blacksmithing. This form of traditional technology has led to modern technology such as mechanized farming, modern wood working, metalworking etc. The pictures below show how indigenous knowledge has contributed to modern technology such as transportation.





Indigenous knowledge has added value to modern technology (A canoe constructed and a vehicle manufactured)
Source: Popp (2018) and Okwori (2023)

Education

Education refers to the act or process of impacting or acquiring knowledge, developing the power of reasoning, judgment and preparing one to earn a living. Education means the discipline that is concerned with the methods of teaching and learning in schools or school-like environment as opposed to non-formal and informal learning (www.britannica.com). Indigenous knowledge provides rich context that can contribute to understanding the relationship between concepts used in classrooms. Indigenous knowledge emphasize traditional instructional methods, apprenticeship and learning through observation. In formal classroom setting and practical lessons in the laboratory, observation is highly emphasized. Teaching using discussion method which is popular in traditional education is also practiced in modern teaching. Numbering or counting using stones or sticks practiced by indigenous people has brought about using machines or electronic devices to perform such calculation. Indigenous knowledge has contributed to the production of modern instruction materials. Chalkboard has been replaced with interactive board. Different audio-visual aids and other instructional materials have been improved on.



Traditional teaching method has added value to modern pedagogy (Discussion method of teaching)

Sources of indigenous knowledge

Indigenous knowledge is obtained from different sources. It can be obtained from stones found in different communities. Other sources of Ik are dances, songs and ceremonies that took place during festivals in the rural areas. It is also obtained from traditional architecture, agricultural system practiced in communities. Similarly, medicine, spiritual and religions institutions found in rural areas are also sources of indigenous knowledge.

Forms of Indigenous Knowledge

Indigenous knowledge is categorized into the following disciplines: agricultural knowledge, medicinal knowledge, bio-diversity-related knowledge and expression of folk-lore in the form of music, dance, song, hand craft and design (Nicholas, White, Mcgregor & Smith, 2017). Indigenous knowledge are preserved against deterioration for present and future use.

Methods of preserving indigenous knowledge materials

Preservation is the process of keeping the item intact or free from damage. Preservation prolongs the life span of an item. It is the act of preserving an item or knowledge in print or recorded form. According to Reitz (2005), preservation refers to prolonging the life of materials by maintaining them in a condition suitable for use, either by making its original form more durable after it has been damaged. IK materials can be persevered through documentation, digitization, video recording, internet and libraries. The other methods employed in preserving IK materials include: good ventilation in the library, cleaning and dusting of material, use of boxes for pamphlet, utilization of binding services, digital archiving and reprography for producing duplicate copies, use of dehumidifiers and as well as use of reformative process and so on.

Other methods employed in preserving IK material in the libraries include: Reformatting of the materials that about to destroy, Use of CD ROM and use of fumigation machine materials. The process of acquiring Indigenous knowledge and skills is different from western education. Therefore, it possesses some characteristics that make it unique.

Characteristic of indigenous knowledge

Indigenous knowledge possesses some characteristics. Below are the characteristics of IK.

a. It is based on experience and it is often tested over time

b. It is not confined to a particular ethnic group but it is based on ideas, practice and information that have been generated. It is passed mostly orally from one generation to other.

c. Cultural Uniqueness: indigenous knowledge is generated within communities. It is unique to a given ethnic group or culture. It is expressed in a language of particular people in a community.

d. Oral transmission: indigenous knowledge is transmitted orally and it covers area like stories, song and dance, tradition, architecture, agricultural system, medicine, spiritual and religions institutions. IK is oral and rural in nature and expressed in local languages.

e. Multi-Faceted: It has many facets such as tools used in agriculture, building construction, health care, development of human resource inform of apprenticeship.

f. It is expressed in form of stories, folklores, cultural value, plant species, art and craft, technology and animal breeds (Mabawonku , 2005& Nicholas, White, Mcgregor & Smith,2017).

Ways of promoting indigenous knowledge in education, science and technology in tertiary institutions

Indigenous knowledge can be promoted through the following ways.

a) Providing enabling environment. Indigenous knowledge should be encouraged by providing enabling environment since many communities rely on it for their survival. This IK is utilized in communities in various areas such as agriculture, medicine, technology etc.

b) Protection. In order to promote indigenous knowledge in the society, it should be protected because of its relevance to education, science and technology in the society. Government should protect IK by formulating an act or law that allows them to practice without restriction as far it is contributing to the development of the society.

c) Patent – Items developed or produced using indigenous knowledge in the area in the area of medicine, agriculture, arts and culture, technology etc by lecturers and others should be patented. This can aid in promoting indigenous knowledge in tertiary institutions.

d).Using print and local languages. IK can be promoted in the society including tertiary institutions by using mass media such as pamphlets, handbills, newspapers. It can also be promoted using local languages through radio and television.

e) School administrators- School administrators can promote indigenous knowledge by encouraging lecturers to carry out researches in various areas of knowledge using indigenous knowledge. He can institute award for lecturers that discover new ideas or invention in their areas of knowledge through indigenous knowledge.

f. Website-Indigenous knowledge can also be promoted by creating website on it. It should be linked to discoveries in various disciplines using indigenous knowledge.

g. Instructional methods- Traditional instructional methods should be used to complement modern method of teaching. This also promotes indigenous knowledge. Due to lack of modern gadgets for teaching, many institutions still embrace traditional method of teaching.

Conclusion

Indigenous knowledge is also known as traditional knowledge. It is the cumulative body of knowledge handed over to generations by people in a community or rural area. It involves observations and it can be in oral and written, innovations, practices, beliefs and so on. The sources of indigenous knowledge include stone, dances, songs and ceremonies, architecture, agricultural system, medicine, spiritual and religions institutions. Many technologies and vaccines or drugs are developed through indigenous knowledge. Therefore, the society will develop more if indigenous knowledge is promoted in tertiary institutions using the school administrators, website, mass media, patent etc. It is essential indigenous knowledge is well preserved for use because of its relevance to the society.

Recommendation

This following are recommended based on the content of the paper.

1. Indigenous knowledge should be promoted in tertiary institutions to enhance more discoveries in education, science, technology and other disciplines.
2. Government should encourage utilizing indigenous knowledge in our society as many communities' survival relies on it. For instance, farming, developing their technologies, treating of illness using herbs or plants etc.
3. Indigenous knowledge should be preserved using various methods for future use.
4. Traditional method of teaching should be used to complement modern methods of teaching in schools as it aids perception of what has been taught in the class.

References

Daniel, R.A.(2022). ''What is indigenous knowledge and why does it matter?''. Integrating ancestral wisdom and approaches into federal decision making. Available online at: www.whitehouse.gov. Retrieved on 2/11/2023.

Defination of science. Available online at: www.britannical.com> scienc. Retrieved on 25th /11/2023.

Defination of technology. Available online at: www.britannical.com> technology. Retrieved on 25th /11/2023.

How indigenous advances modern science. Available online at:https://theconversion.com>how-indigenous knowledge. Retrieved on12/10/2023

Jigam, A. A. (2016). Malaria: The use of phytomedecines as a viable alternative management strategy for an Africa and third world tragedy. 49th Inaugural lecture Series of Federal University of Technology, Minna, Nigeria.

Popp, J. (2018). How indigenous knowledge advances modern science and technology.Available online at: https://www,researchgate.net/publication/349961351.

Mabawwonku,I.(2005).Promoting indigenous knowledge publishing Nigerian language. The role of library and information professionals. A paper presented at Nigerian international book fair 11.

Meaning of indigenous knowledge. Available online at: en.m.wikipedia.org. Retrieved on 10th /11/2023.

Nicholas,J.R, Kyle,P.W, McGregor, D &Smith, M.A.(2017). Factors that support indigenous involvement in multi- actor environmental stewardship. Available on line at: www.researchgate.net. Retrieved on 9th/11/2023.

Ohize, E.J. (2016). Industrial and technology education: The missing link to industrial development.44th Inaugural lecture Series of Federal University of Technology, Minna, Nigeria.

Okwori, R.O. (2023). Identification of methods for assessing the most effective and relevant strategic training among public and private sector TVET providers for capacity development of technical teachers and instructors(TTIs). A paper presented at HRSSD Stakeholders' sensitization workshop of the IDEAS Project held at Gombe Intercontinental Hotel, Gombe on 20th to 22nd February.

Reitz, J.M. (2005).Dictionary for library and information science.Westport: Libraries Unlimited.

Udensi, J.N. (2017). Cultural information: A gateway to sustainable development in Africa. Inaugural Lecture Series 55. Minna: Federal University of Technology.

INFORMATION AND COMMUNICATION TECHNOLOGY INTERACTION AND LANGUAGE THROUGH COMPUTATIONAL TERMINOLOGY

BELLO, Yekeen
Department of Arts Education,
Faculty of Education,
University of Ilorin, Ilorin, Nigeria
bello.y@unilorin.edu.ng

+2348065241336

Abstract

The thrust of this paper is an overview of information and communication technology interaction and language through computational terminology generated through electronic medium. The advent of each new computational stage provides different language situations, whose functionality in new roles implies linguistic analysis, such as for terminology extractions or electronic discourses. Based on the approach to aspects of computational terminology, the study emphasised the importance of choosing the appropriate technical and linguistic methods, in order to acquire efficiency in established contacts between computer and language more so that everybody says computer has made the entire world a "global village", whereas a village is a close-knit community, traditionally identified by a local dialect or language which distinguishes its members from other people elsewhere. If there is to be a genuine global village, then we need to ask 'What is its dialect?', 'What are the shared features of language which give the world community of users their sense of identity?' And, if we cannot discern any unifying dialect or language or a trend toward such a unity, we need to ask ourselves if this "global village" is anything more than a media fiction". However, computational terminology has made computer users to speak one same language following the adoption of smileys different from the known global linguistics. Based on these, it is therefore concluded and recommended that the fate of computer terminology may be determined by the evaluation through knowledge, in a phase of rapid evolution. It has been observed that the representation of computational terminology reflects important purposes for linguists implied in this field, in the construction of which language activities and results no doubt contribute, and that since network utilisation of terminology is an innovative method that has helped to identify and create new terms, and such projects must be undertaken to accomplish the demands of producing a terminology.

Keywords: Universal language, Internet culture, Computational terminology and Global village

Introduction

The advent of information and communication technology (ICT) as communication evolutionary changes the feelings of world communication system which has ushered in excitement in all spheres of human endeavour. Although the computer is a machine that is capable of executing and processing instructions on a particular data or an electronic device for storing and processing on another data, still this is not the reason why we are part of the Information Era (Sam, 2021). This therefore, reveals other important reasons which connect computers to human lives, i.e. storing data, managing complex communication environments, processing images and sounds, among several other things. Computers have very important in

this modern world, and also proven to be very useful tools in academics, industrial, government environments, their efficiency being recognised in almost every activity embarked upon by man (Crystal, 2009).

According to Covington (2009), the importance and increasing use of the Internet, considered to be the world's largest computer network, is having general and individual effects on language, as a direct result of the new ways of communication, substantially different from other semiotic acts. Before the Internet adventure began, there were only two ways to send and receive information i.e. by reading or verbal communication. The nature of the electronic medium, along with the Internet technologies, contributed to the dissemination of information among people around the world, becoming widely available. It is therefore pertinent to know that the case and situations of Internet communications involve linguistic consequences, once the individuals who take part in this do not share the same culture. A similar point is made by Crystal (2009) in *Language and the Internet*, where, starting from the notion of global village assigned to the Internet community contends that there has been much talk of the notion of a "global village", which is at first sight a persuasive metaphor. Yet such a concept raises all kind of linguistic questions. A village is a close-knit community, traditionally identified by a local dialect or language which distinguishes its members from other people elsewhere. If there is to be a genuine global village, then we need to ask 'What is its dialect?', 'What are the shared features of language which give the world community of users their sense of identity?' And, if we cannot discern any unifying dialect or language or a trend toward such a unity, we need to ask ourselves if this "global village" is anything more than a media fiction",

To explore the way in which the concept of "global village" finds its linguistics expression, we need to take into account the global spread of language that seems to affect the existence of billions of people worldwide. This is meant to highlight the fact that, nowadays, English is the world's leading language, being used in many countries. It is used on all continents. Surprisingly, many countries (more than 100, according to recent estimates) has important internal functions as Second Language (L2) in addition to one or more indigenous tongues, being used in politics, businesses, education, technology, the media, etc. (Antia, 2000). This is an indicator that might establish the existence of a universal language, whose functions, at the level of the Internet medium, improve conditions for global communication, and turns out to be highly successful. All these observations need to be related to the growth of the Internet culture, a worldwide phenomenon that reflects different backgrounds of the users, constrained by their status to confront various Internet situations.

Background Literature

As a discipline, terminology is concerned with the study of terms, their formation, usage, significance, evolution, their linguistic aspects representing a major-interest to terminologists and specialists, as well as to the translators (John, 2022). In addition, researchers from different fields of study have strong interests to develop and maintain a terminological rigour, in order to provide a precise understanding. In terms of needs, the task of creating terminologies is clearly illustrated in Recent Advances in Computational Terminology, edited by Bourigauld (2001); Christian (2001) and Marie-Claude (2001). In another development, Milhai (2023) asserts that information science specialists, lexicographers, translators, as well as other specialists, such as engineers, scientists and technicians have experienced the need to improve communication, or to access subject specific information. Terminological (or several types terminology-related) of resources, such as specialised dictionaries, term banks, glossaries and thesaurus, have been built in order to satisfy these needs. Based on the above, it is understood that such needs would be an

important source of purposes in computational terminology, a field that requires both theoretical and practical approaches, whose implications lead to identification of terminological units (referring to the automatic or semiautomatic ways of linguistic approaches at the text level) and finding the semantic and conceptual information on terms (the linguistic operation after the terms have been extracted).

The automatic extraction of terms from specialised texts was a real challenge for terminology extraction (TE), motivated by the large number of textual corpora in language processing, as from the moment of appearance of termino (term detector) in 1990, specialist showed their interests in development of software tools specialised in terminological field. Although there are different approaches for automatic term detection and extraction, the demands of creating this type of programmes require common type of information, as they create possibilities of dealing with electronic texts. Systems of terminology extraction exemplify the potential of computer technology, using linguistics elements; in fact, the field is wide open for new initiatives, inspired by such mechanisms. Based on this view, Castellvi and Palatresi (2021) describe some systems of terminology extraction, pointing out their positive and negative features. The architecture of the semiautomatic extraction system, called ANA (Automatic Natural Acquisition), having as components two modules: "a familiarity module" and "a one". The first module is based on three groups of words, while the discovery module, representing the process of creating the semantic acquisition, (whose main goal is to detect and generate terms) depends on three types of interpretation of the identified words. The construction of the familiarity module contains the following groups of words:

a. function words (i.e. empty words) such as a, a*ny, for, in, is, of, to...*

b. scheme words (i.e. words establishing semantic relationships) such as *box of nails*, where the preposition shows some kind of relationship between *box* and *nails*.

c. bootstrap (i.e. set of terms that constitutes the kernel of system and the starting point for term detection).

In other words, this familiarity module has an important role in the extraction system, and can be expressed as the predefined part of it. Furthermore, the discovery module involves generated terms, serving as an identifier to other activity (first module); the second module can be seen as a term selection linked to three types of word interpretation: *expression, candidate* and *expansion*. Term Expression (T_{EXP}) deals with the frequency of the existing terms, every new word being added to the semantic network; Term Candidate (T_{CAND}) represents the situation when an existing term is framed to be a new word inside the system, because it appears next to another word; Term Expansion (T_{EXPA}) oversees terms identified in the same word sequence. But, for providing an explicit view, illustrations of the previous types of word interpretation of the involved system, will be made, making use of the following examples and figures:

i. Expression - for instance, if an entity has sparrow or eagle as subordinate and bird as the supper ordinate, known terms and find sequences like the Bird is...or... this sparrow or eagle has...Then the sequence sparrow or eagle is accepted as a new term and is included in the semantic network as a new node with links to Bird.
ii. candidate - an existing term appears frequently together with another word and a scheme word as in:... any Tree of wood...or... this Tree... or this Tree... here wood becomes a new term and is placed in a new node of the semantic network.
iii. expansion - an existing term appears frequently in the same word sequence, without including any scheme word: use any soft woods to... or... this soft woods or... as a result, soft wood is incorporated into the term list and the semantic network as a new node with a link to woods (Sanderson, 2023).

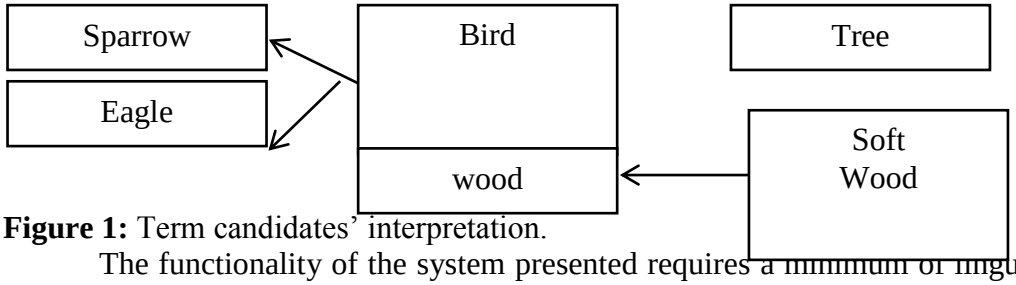


Figure 1: Term candidates' interpretation.

The functionality of the system presented requires a minimum of linguistic resources, aspect that facilitates an accessible usage, but, this is not the only condition for a positive feedback. In fact, this system does not assure a completed validation of the terms, and, more importantly, it gives the possibility for non-valid terms to be included to the term list. Still, it is quite natural to think that, despite all negative features, this system could be a pretext for improving computer technology, to create new mechanisms of (semi)automatic term extractions. Perhaps greatest importance of the system is its existence, as to improve terminology extraction, a starting point is needed. Broadly speaking, the efficiency of this type of systems was not clearly measurable. Under these circumstances, the progress in the field of computational terminology needs to combine in a more active manner technical and linguistic methods (Downinggai, 2022).

Linguistics and Internet Terminology

Drillee (2019) claims that as more and more individuals become part of the Internet communion almost everyone is familiar with e-mail, chat groups or blogging, forms of electronic interactions, whose linguistic features depend on style, purpose, audience, among several other usages. Thus, the relations between computer and linguistics must be perceived as an important interaction, focusing on developing software's for linguistics, of which the reason for computing metaphor works so well is that language truly is a form of software. Just as the human brain was the model for computer hardware, human language was the model for computer software - and we are now, after a decade of widespread, intensive experience with computers, in a position to recognise what that means. Linguistics and computer in various fields of human endeavour, including hardware and software industries, promote their common goals, allowing us to gather efficiently all kind of information, the relation between linguistics and computer involving a close cooperation between the two types of users.

The language of Internet according to Dan (2022), displays the process of writing in its different forms, depending on users' possibilities of expression, knowing that the communicative problems within e-discourses of all kinds could affect language usage. But there are no specific ways of predicting language-using situations, as it is evident that Internet users are still in learning situations. As a result, a conventional Internet behaviour, in the sense of general agreed models, is required to avoid linguistic problems. The larger the number of Internet users is, the various the situations become. Here, therefore, we find stylistic approaches that identified five main features for written language (also found in Internet written situations): graphic, orthographic, grammatical, lexical, and discourse features, and another two features for the spoken language (identified on the Internet through songs, videos, films, etc.): phonetic and phonological features:

a. Graphic features appear inside written language as different typography, font, size, alignment, colour, contrast, white space, along with other elements which define the creation of the pages.

b. Orthographic features (also called graphological features) are the specific aspects of using the alphabet, according to every language, many ways of expressing being considered (spelling, punctuation, etc.).
c. Grammatical features expose various systems of languages, and thus, elements of Morphology (word structure) and Syntax (sentence structure).
d. Lexical features set clear distinction between vocabularies of different languages or even varieties within one language
e. Discourse features are based on cohesion (organisation of the discourse), and coherence in terms of logical exposition of ideas, relevance.

Spoken language on the Internet has a strong presence through videos, songs, webcams, because of the continuous technological development. We are encountering spoken language situations, and phonetic and phonological features can be easily observed as follows: phonetic features are connected to the particular series of tones in the human voice, while the phonological features deal with sound systems of language (Dias & Diaz, 2023).

Netspeak as a Terminology

Netspeak" is a term coined by Crystal (2020), made to represent Internet communication, indicating that "speech" includes action of writing as well; Internet language has to be represented by specific features of the electronic medium, so "Netspeak" comes to assume linguistic Internet situations. It should be noted that features of Netspeak were identified outside the Internet, influencing vocabulary in everyday communication. As a matter of fact, computer terminology comprises terms that were adapted to the speaker needs, so the special vocabulary used by programmers was extended to everyone's life. Accordingly, we do hear often and often the term "dot com (.com), forward, slash, www", and examples like "Let's talk offline (meaning let's talk in private)" or "He is multitasking (in the sense of doing two things at once)".

In the case of electronic interactions like e-mail, chatgroups, netspeak make use of expressions to send and even exaggerated nuances of feelings, moods, ideas, through symbols called smileys or emoticons, which are created through combination of keyboard characters. Beyond their expressive qualities, smileys seem to complete language in an innovative way, since written language has always been an impossibility of using facial expression. Sanderson (2023) involves even personality features when he describes smileys, making the following statement: "You might include a smiley as a reminder of the ongoing context of any conversation, to indicate that your words do not stand on their own. A smiley can point out to the other participants of the conversation that they need to understand you and your personality in order to understand what you have said". With an impressive collection of over 650 smileys compiled over the years, Sanderson finds interesting meanings for computer characters as shown in Table 1 below:

Table 1: Examples of smileys (after Sanderson)

Basic smileys	
:-)	Pleasure, honour, etc.
;-)	sadness, dissatisfaction, etc.
;-)	winking (in any of its meaning)
8-)	crying
B:-)	confused
:-0	shocked, amazed
	Sarcastic
Joke smileys	
:*)	user is wearing a walkman
:-[	user is wearing sunglasses

:-E	user is wearing sunglasses on head
:-F	user is drunk
(+-:-)	user is a vampire
0 :-)	user is a bucktoothed vampire
	user is a bucktoothed vampire with one tooth missing
	user has a cold
	user is screaming
	user is a punk
	real punk don't smile
	user holds a Christian religious office
	user is an angel at heart

Smiley stories

:-) 8-) 8-()	A smiley to disguise himself gets glasses and a fake moustache
C:-) >[] C8-)	A smart smiley left watching too much TV

All these interactive ways of communication attempt to display users' potentials, facilitating a kind of language revitalisation. As we have seen, the enormous expansion of the Internet determined a great creativity, enriching the community's linguistic norms.

Immediate innovation in the field of computational terminology has a clear impact on the kind of language we use. Many new technologies are anticipated, and arena of communication will always involve constant pressure for the adaptation to the new contexts. Internet observers therefore predict conversational openings, when we will have to get used to new models of communication. Certainly, the participants of Netspeak seem to be aware of the fact that they are still in learning situations as long as communicative potential determines new rules and roles. The linguistic dimension will take time to evolve, in a field where technology continuous changes play a central role, especially among users forced to learn if they want to join this Internet community. When the survival and success on the Netspeak cannot be assured by the simple use of language, the user becomes interested in the everyday realities. The experience of language, along Netspeak is far from ending, so the computer-mediated language remains the core of interactions inside this environment.

Conclusion

Every computer contains information in some language, and data in language can be represented in different forms, according to application software. This is the reason why, as noted above, language and computer contact frequently support each other under the influence of advances in technological field. The fate of computer terminology may be determined by the evaluation through knowledge, in a phase of rapid evolution. It has been observed that the representation of computational terminology reflects important purposes for linguists implied in this field, in the construction of which language activities and results no doubt contribute.

Recommendations

Given this reality, then, a convenient starting point is represented by systems of terminology extraction. As long as a basis for these systems has been established, specialists have the advantage of building new mechanisms for (computational) terminology. It might be pointed out that besides the semiautomatic systems for terminological extractions Internet situations provide an appropriate environment for performing further researches to obtain specialised terms. Text acquisition for terminological exploitation is a complex process that falls within the linguistics and computers, based on a conceptual structure. In computer medium, the question of language representation is accessed and applied through professional

users, and widespread even at the level of common language. Network utilisation of terminology is an innovative method, that has helped identify and create new terms, and such projects must be undertaken to accomplish the demands of producing a terminology. In a phase of rapid evolution, computer terminology reports advances in both language and computer, sustained by continuous emergence of new resources.

References

Antia, T.F. (2000). Terminology and Language Planning: An alternative framework of practice and discourse. John Benjamins Publishing Company, Amsterdam/Philadelphia.

Bourigauld, O.J. (2001). Computational Terminology, John Benjamins Publishing Company, Amsterdam/Philadelphia.

Castellvi, L. & Palatresi, P. (2021). *The Computers History and Architectures*, the MIT Press Cambridge, Massachusetts, London, England, 2000.

Christian, D.D. (2001). *Recent Advances in Computational Terminology.* John Benjamins Publishing Company, Amsterdam/Philadelphia.

Covington, C.J. (2009). Dictionary of computer and internet terms, tenth edition. *Baroon's Educational Series*, NY.

Crystal, D. (2009). *Language and the Internet, Second Edition*, Cambridge University Press, New York.

Dan, N.L. (2022). Students' learning style in two classes. Online learning and the computer class. Baroon's Educational Series, NY.

Dias, F. & Diaz, Y.W. (2023). English around the world, Cambridge University Press, New York, 2011

Downinggai, D.G. (2022). Covington, Michael; Covington, Melody Mauldin, *Dictionary of Computer and Internet Terms*, Tenth Edition, Baroon's Educational Series, NY.

Drillee. H. (2019). Terminologie Constitution des données, Afnor Gestion, Paris.

John, P. (2022). Using computers in linguistics a practical guide. Routlage, London and New York.

Marie-Claude, U. (2001). Automatic term detection in computational terminology. Oxford University Press, New York.

Milhai, B. B. (2023). The making of typographic man, Routlage and Kegan Paul, London.

Sam, O.P. (2021). Information and communication technology era. John Benjamins Publishing Company, Amsterdam/Philadelphia

Sanderson, D. M. (2023). Smileys, O'Reilly and Associates, Sebastopol.

SUB-THEME 8
AGRICULTURAL TECHNOLOGY

ENTREPRENEURIAL SKILLS REQUIRED BY AGRICULTURAL EDUCATION STUDENTS IN TERTIARY INSTITUTIONS IN KANO STATE FOR OPTIMAL SUCCESS IN SHEEP HUSBANDRY PRACTICES

Idi Garba, PhD
Department of Science and Technology Education,
Faculty of Education,
Bayero University, Kano, Nigeria
2348065991335

Abstract

Sheep are among the first animals to have been domesticated by humans. Their history goes back to between 11,000 and 9,000 BCE. Sheep are raised both in villages and towns and by pastoralists in Kano State and other States of Nigeria. This study was designed to identify the entrepreneurial skills required by agricultural education students in tertiary institutions in Kano State for optimal success in sheep husbandry practices. The study used survey research design. Three research questions and three null hypotheses guided the study. The population for the study was 172, comprising 24 Animal Science Technologies and 148 Agricultural Science Lecturers in public tertiary institutions in the State. All the 24 Animal Science Technologies were involved in this study, while 108 Agricultural Science Lecturers were selected as sample size for the study. A questionnaire was used as instrument for data collection, validated by three experts. Pilot study was conducted to determine the reliability of the instrument, a coefficient of 0. 73 was obtained. Mean scores were used to answer the research questions while t-test statistic was used to test the null hypotheses at 0.05 level of significance. The findings of the study revealed that all 34 items identified for feeding, health and production management practices were required as entrepreneurial skills for optimal success in sheep husbandry practices. Based on the findings, it was recommended that Lecturers in tertiary institution in Kano State should focus on essential skills for sheep husbandry practices.

Keywords: *Entrepreneurship, entrepreneurial skill, agricultural, sheep husbandry*

Introduction

Entrepreneurship is a process of bringing together creative and innovative ideas and exploring management and organizational skills to combine people, money and resources to meet an identified need and thereby create wealth. It could also be seen as a process that involves a team of people who combine their skills and resources in productive ventures (Danladi & Okoro, 2016). Entrepreneurship is not just skill acquisition for acquisition's sake. It is an acquisition of skills and ideas for the sake of creating employment. According to Dorothy (n.d.), unemployment is one of the major issues affecting Nigeria's National development. To solve the problems of unemployment, teaching and learning of entrepreneurship skills become paramount interest to all stakeholders. Entrepreneurship skills are specialized technical knowledge that entrepreneurs should possess in order to perform their roles and these skills are acquired through learning and experience. They are set of specific knowledge, abilities, skills, traits, motives, attitudes and values required for the personal development and successful participation of each person in an organization (Khamis & Alhassan, 2020). Hisrich and Peters (2012) as cited in Bako et al. (n.d.) further revealed that entrepreneurial skill acquisition can be defined as the ability to create something new with value by devoting the necessary time and effort, assuming the accompanying financial, psychic and social risks, and receiving the resulting rewards of monetary and personal satisfaction and independence. The inclusion of entrepreneurship skill acquisition in the tertiary institutions' curriculum

would bring about sustainable development in vocational agriculture. Agriculture is the science, art and business of cultivating soil, producing crops and rearing livestock for human use. Sheep are among the major economically important livestock in Nigeria.

Sheep rearing is a profitable and rewarding venture for farmers. According to report produced by Livestock Producers (2013), sheep are raised primarily for their meat and wool, although their milk products are gaining in acceptance and economical importance. Sheep can produce two to three litres of milk daily rich in Calcium, Magnesium, Phosphorus, Potassium and Sodium. It also has small amount of Selenium, Zinc and Iron. Rich in Vitamin A, C and Folate. It has small amount of Thiamin, Riboflavin, Niacin, Vitamin B6, Vitamin B12 and Pantothenic acid. On average, it is more nutritious than cow's or goat's milk. Space and feed requirements are very low compared to cattle and also have minimum risk and easy management practices. Their low feed and labour requirements make them a desirable choice for millions of smallholders globally. Being small-sized animals, sheep require a small initial investment. The small size, together with early maturity, makes sheep suitable for meeting subsistence needs for meat and milk. In general, they have lower feed and water requirements. Because of their high reproductive rates, flock numbers can be restored more rapidly post-loss. Due to their short reproductive cycles (short lambing interval) and high multiple births, there is potential for a higher annual off-take of sheep than seen with cattle. This allows farmers/producers a quick interval of selling part of their flock and generating cash income.

Commonly, rural areas have no formal banking facilities. Cash resources are quickly converted to livestock as a form of wealth accumulation or savings. Sheep because of their relative value and high security (i.e. survivability) are the asset form of choice for many smallholders in villages. In fact, in some areas, small ruminants have been described as the 'village bank'. For smallholder farmers, sheep have high income earning potential. Multiple (twins, triplets) offspring are typically born every year and commonly twice per year. Even for households with small land-holdings or minimal access to grazing areas, sheep are a viable livelihood. Because of their easy access to markets and large cash payouts, farmers will sell sheep to pay for medium to large household expenses such as school fees, hospital bills, and crop inputs. Drug doses requirements are small because of the animal's small size. This is a good alternative livelihood opportunity for people who do not have a lot of money to start with/the business can be started with small capital. Sheep eat many different plants including plants with relatively low nutritional value; making them easier to feed through the year and require less labour and time per head compared to cattle (Livestock Producers,2013).

Statement of the Problem

Agricultural development is directed toward supporting food security, increase productivity and value-added products of livestock, plantation, fishery and forestry to improve the welfare of farmers. Among the sectors of agriculture, livestock becomes one of the foundations of agricultural development, Sheep are among the major economically important livestock in Nigeria. Sheep have many advantages, including the characteristics of the meat which has the benefit of preventing anemia, muscle building and improving the immune system (Rachmat, 2016). According to Richard (2023), sheep producers ought to have skills and knowledge about sheep so as to improve their sheep management skills, increase their chances of a profitable sheep enterprise or gain employment. The issue of unemployment was further aggravated by the fact that Nigeria education system as inherited from colonial master failed to equip her graduates with the skills needed to create jobs. The government in her bid to reduce unemployment introduced entrepreneurship in the school curriculum. The inclusion of entrepreneurship education in tertiary institutions in Nigeria shows its importance in jobs creation. Nigeria tertiary institutions produce large number of graduates annually into an

economy which is already overpopulated. Experience over the years has revealed that 70% of these graduates end up roaming about in the street as a result of lack of job opportunities (Bako *et al.*, n.d.), therefore, the unemployment rate keeps on increasing each year into the society. It is based on this background that this study intends to determine the entrepreneurial skills required by agricultural education students in tertiary institutions in Kano State for optimal success in sheep husbandry practices.

Methodology

The study was designed to identify the entrepreneurial skills required by agricultural education students in tertiary institutions in Kano State for optimal success in sheep husbandry practices. The study made use of survey research design. Three research questions and three null hypotheses guided the study. The population for the study was 172, comprising of 24 Animal Science Technologies and 148 Agricultural Science Lecturers in public tertiary institutions offering Agricultural Education Programme in the State. All the 24 Animal Science Technologies were involved in this study, while 108 Agricultural Science Lecturers were selected using proportionate random sampling technique as sample size for the study. Research Advisors Table guided the researcher in selection of the sample size. A questionnaire tagged Entrepreneurial Skills Required in Sheep Husbandry Practices (ESRSHP) was the instrument used for data collection adapted on four rating scale; strongly agree, agree, disagree, and strongly disagree with corresponding values of 4,3,2, and 1 respectively, which was validated by three experts. Pilot study was conducted and Pearson Product Moment Correlation was used to determine the reliability of the instrument, a coefficient of 0. 73 was obtained. A 132- copies of the questionnaire were distributed with help of four research assistants to the respondents by hand and the completed questionnaires were collected back on the spot. all the copies of the questionnaire distributed were successfully returned. Mean scores were used to answer the research questions while t-test statistic was used to test the null hypotheses at 0.05 level of significance.

The decision rules were that, in answering the research questions, any item whose mean score was found to be 2.5 or above, was considered to be "Required" hence regarded as the knowledge and the skills required, while any item whose mean score was found below 2.5, was considered to be "Not Required" hence regarded as not knowledge and skills required. The decision on testing the null hypotheses was based on comparing the computed p-value (Sig.) and 0.05 levels of significance. If the computed p-value (Sig.) is equal to or less than 0.05 levels of significance the null hypothesis was considered rejected, but accepted if the computed p-value (Sig.) is greater than 0.05 level of significance.

Objectives of the Study

The general purpose of the study was to determine entrepreneurial skills required by agricultural education students in tertiary institutions in kano state for optimal success in sheep husbandry practices. The specific objectives are to;

1. determine the entrepreneurial skills required for feeding management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State,
2. determine the entrepreneurial skills required for health management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State,
3. determine the entrepreneurial skills required for reproduction management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State.

Research Questions 1

1. What are the entrepreneurial skills required for feeding management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State?
2. What are the entrepreneurial skills required for health management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State?
3. What are the entrepreneurial skills required for reproduction management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State?

Hypotheses

The following null hypotheses were formulated and tested at an alpha (α) level of 0.05

1. There is no significant difference between the mean opinions of agricultural Science Lecturers and Animal Science Technologies on the entrepreneurial skills required for feeding management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State.
2. There is no significant difference between the mean opinions of agricultural Science Lecturers and Animal Science Technologies on the entrepreneurial skills required for health management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State.
3. There is no significant difference between the mean opinions of agricultural Science Lecturers and Animal Science Technologies on the entrepreneurial skills required for reproduction management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State?

Results

Research Question one: What are the entrepreneurial skills required for feeding management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State?

Data for answering research question one are presented in Table 1.

Table 1: Mean Ratings of Respondents on the Entrepreneurial Skills Required for Feeding Management Practices in Sheep Husbandry by Agricultural Education Students in Tertiary Institutions in Kano State, (n = 132).

S/N	Entrepreneurial Skills	$\bar{X}$	SD	Decision
1.	Become familiar with types of feeds and their nutrient values.	3.33	0.69	Required
2.	Recognize common nutritional disorders of sheep.	2.99	0.89	Required
3.	Know how to efficiently feed sheep for optimum performance.	3.01	0.79	Required
4.	Become familiar with a balance feed ration for feeder lambs.	2.97	0.74	Required
5.	Become familiar with a balance feed ration for a pregnant ewe.	3.00	0.81	Required
6.	Know how to train a lamb to drink from a bottle (when applicable).	2.79	0.70	Required
7.	Know basic feed composting techniques.	3.45	0.77	Required
8.	Become familiar with proper grain need for additional feed.	2.98	0.93	Required
9.	Become familiar with proper hay need for feed/additional feed.	3.11	0.95	Required

10.	Be able to evaluate a pasture for forage quantity and quality	2.88	0.71	Required

$\bar{x}$= mean, SD = Standard deviation, R = Required, n = number of respondents

Data presented in Table 1 reveal that the mean ratings of respondents for all the 10 items range from 2.79 to 3.45 are above 2.50 on 4-point rating scale. This implies that the respondents agreed with all the items as the entrepreneurial skills required for feeding management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State. The standard deviations for the 10 items that range from 0.69 to 0.95 shows that the responses of respondents were closed to one another.

Null Hypothesis one: There is no significant difference between the mean opinions of agricultural Science Lecturers and Animal Science Technologies on the entrepreneurial skills required for health management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State.

Table 2: Summary of t-test Analysis of the Difference Between the Mean Ratings of Agricultural Science Lecturers and Animal Science Technologies on the Entrepreneurial Skills Required for Health Management Practices in Sheep Husbandry by Agricultural Education Students in Tertiary Institutions in Kano State.

Status	N	Mean	SD	Df	Level of Sig.	t-value	Decision
Agricultural Science Lecturers	108	18.48	1.76	130	0.05	0.15	Accepted
Animal Science Technologies	24	18.77	1.49				

The results in Table 2 show that the entrepreneurial skills required for health management practices in sheep husbandry from the opinions of two groups of respondents (Agricultural Science Lecturers and Animal Science Technologies) in tertiary institutions in Kano State did not differ significantly. In other words, the null hypothesis was not rejected. This is because the t-value 0.15 is greater than 0.05 level of significance.

Research Questions two: What are the entrepreneurial skills required for heath management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State?

Data for answering research question 2 are presented in Table 3.

Table 3: Mean Ratings of Respondents on the Entrepreneurial Skills Required for Heath Management Practices in Sheep Husbandry by Agricultural Education Students in Tertiary Institutions in Kano State, (N= 132).

S/N	Entrepreneurial Skills	$\bar{X}$	SD	Decision
1.	Recognize a normal temperature of healthy sheep.	2.99	0.90	Required
2.	Know how to recognize a sheep that is sick.	3.55	0.75	Required
3.	Know how to take rectal temperature of sheep.	2.92	0.97	Required
4.	Know how to correctly give an intramuscular injection.	3.66	0.71	Required
5.	Know how to administer an oral de-wormer.	3.77	0.88	Required
6.	Know how to properly trim hooves.	2.78	0.70	Required
7.	Become familiar with common sheep diseases in your area.	2.88	0.74	Required
8.	Restrain an animal without stressful treatments.	2.87	0.86	Required
9.	Recognize plants poisonous to sheep in your area.	2.78	0.58	Required
10.	Know how to trim the horns of adult rams.	2.94	0.81	Required
11.	Know how to pare sheep's feet.	2.68	0.77	Required
12.	Know how to castrate male lambs.	3.00	0.89	Required

13.	Know how to correctly give subcutaneously injection.	3.62	0.72	Required

$\bar{x}$= mean, SD = Standard deviation, R = Required, n = number of respondents

Data presented in Table 3 reveal that the mean ratings of respondents for all the 13 items range from 2.68 to 3.66 are above 2.50 on 4-point rating scale. This implies that the respondents agreed with all the items as the entrepreneurial skills required for health management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State. Standard deviations for the 13 items range from 0.58 to 0.97 indicated that the respondents were closed to one another in their opinions.

Hypothesis two: There is no significant difference between the mean opinions of agricultural Science Lecturers and Animal Science Technologies on the entrepreneurial skills required for management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State.

Table 4: Summary of t-test Analysis of the Difference Between the Mean Ratings of Agricultural Science Lecturers and Animal Science Technologies on the Entrepreneurial Skills Required for Health Management Practices in Sheep Husbandry by Agricultural Education Students in Tertiary Institutions in Kano State.

Status	N	Mean	SD	Df	Level of Sig.	t-value	Decision
Agricultural Science Lecturers	108	21.75	1.99	130	0.05	1.64	Accepted
Animal Science Technologies	24	19.67	1.76				

The results in Table 4 show that the entrepreneurial skills required for health management practices in sheep husbandry from the opinions of two groups of respondents (Agricultural Science Lecturers and Animal Science Technologies) in tertiary institutions in Kano State did not differ significantly. In other words, the null hypothesis was accepted. This is because the t-value 1.64 is greater than 0.05 level of significance.

Research Question three: What are the entrepreneurial skills required for reproduction management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State?

Data for answering research question 3 are presented in Table 5.

Table 5. Mean Ratings of Respondents on the Entrepreneurial Skills Required for Reproduction Management Practices in Sheep Husbandry by Agricultural Education Students in Tertiary Institutions in Kano State, (N= 132).

S/N	Entrepreneurial Skills	$\bar{X}$	SD	Decision
1.	Recognize when an ewe is about to give birth.	3.33	0.78	Required
2.	Recognize a normal birth.	3.56	0.57	Required
3.	Recognize abnormal birthing (dystocia).	3.00	0.99	Required
4.	Know how to disinfect newborn's naval cord.	2.97	0.87	Required
5.	Be able to recognize and treat a retained placenta.	3.02	0.67	Required
6.	Know how to perform basic first aid on a sheep/lamb.	3.65	0.90	Required
7.	Know how to handle a newborn lamb safely.	3.77	0.89	Required
8.	Calculate/estimate time of lambing from breeding date.	2.87	0.94	Required
9.	Become familiar with reproductive tract diseases common. to sheep, how they are spread and how they can be prevented	3.45	0.72	Required
10.	How to protect yourself and workers from zoonotic disease.	3.07	0.87	Required
11.	Develop a working relationship with a local veterinarian.	3.05	0.68	Required

$\bar{x}$= mean, SD = Standard deviation, R = Required, n = number of respondents

Data presented in Table 5 reveal that the mean ratings of respondents for all the 11 items range from 2.87 to 3.65 are above 2.50 on 4-point rating scale. This implies that the respondents agreed with all the items as the entrepreneurial skills required for reproduction management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State. The standard deviation ranged from 0.57 to 0.99 indicates that the respondents were not too far from the mean and from the opinion of one another in their responses.

Hypothesis three: There is no significant difference between the mean opinions of agricultural Science Lecturers and Animal Science Technologies on the entrepreneurial skills required for reproduction management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State.

Table 6: Summary of t-test Analysis of the Difference Between the Mean Ratings of Agricultural Science Lecturers and Animal Science Technologies on the Entrepreneurial Skills Required for Reproduction Management Practices in Sheep Husbandry by Agricultural Education Students in Tertiary Institutions in Kano State.

Status	N	Mean	SD	Df	Level of Sig.	t-value	Decision
Agricultural Science Lecturers	108	19.74	1.07	130	0.05	0.62	Accepted
Animal Science Technologies	24	20.33	1.26				

The results in Table 6 show that the entrepreneurial skills required for reproduction management practices in sheep husbandry from the opinions of two groups of respondents (Agricultural Science Lecturers and Animal Science Technologies) in tertiary institutions in Kano State did not differ significantly. In other words, the null hypothesis was not rejected. This is because the t-value 0.62 is greater than 0.05 level of significance.

Discussion of Findings

The findings of the research question one in Table 1 revealed that the entrepreneurial skills required for feeding management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State are; ability to recognize common nutritional disorders of sheep, know how to efficiently feed sheep for optimum performance, become familiar with types of feeds and their nutrient values, know basic feed composting techniques, be able to evaluate a pasture for forage quantity and quality, become familiar with proper hay need for feed/additional feed, become familiar with proper grain need for additional feed, know how to train a lamb to drink from a bottle (when applicable), become familiar with a balance feed ration for a pregnant ewe and become familiar with a balance feed ration for feeder lambs.

These findings are in line with that of Livestock Producers (2013) who reported that Nursing ewes need special attention. Lactating animals and those recovering from giving birth need to be fed sufficient quantities of hay and concentrate to meet the high nutritional and energy requirements during early lactation. There is also a need to provide plenty of clean, fresh drinking water for the animals. A sheep will consume anywhere from 3-12 litres of water per day, depending upon its physiological state and the environmental conditions. The Livestock Producers (2013) further pointed out that feeding sheep on the ground in a confined space encourages disease transmission and feed waste. feed should not be put on the ground instead a feeding rack should be included in the pen. sheep eat grass, clover, forbs, and other pasture plants, do not eat feeds that are not fresh, have been trampled on, or are somehow viewed as ‘dirty’. (e.g. grass with mud splash from rain) and also prefer not to eat sticky, mouldy or wet

dusty feeds. Sheep feed only on clean, fresh and dry fodder that does not have mould, excessive dust/dirt. For confined animals, feed sheep at least 3 times a day and at the same time every day. The requirements will change depending on the season. Intake of colostrum 'first milk' is crucial for successful rearing of lambs. It has to be fed during the first 24 hours; If ewe has inadequate colostrum, cow colostrum can be given.

The findings of the research question two in Table 3 showed that the entrepreneurial skills required for health management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State are; recognize plants poisonous to sheep in your area, know how to recognize a sheep that is sick, become familiar with common sheep diseases in your area, restrain an animal without stressful treatments, recognize a normal temperature of healthy sheep, know how to take rectal temperature of sheep, know how to administer an oral de-wormer, know how to correctly give an intramuscular (IM) injection, know how to correctly give subcutaneously injection, know how to castrate male lambs, know how to properly trim hooves, know how to trim the horns of adult rams and know how to pare sheep's feet.

The findings are in agreement with the findings of Lloyd and Playford (2013) who revealed that to restrain an animal, avoid shouting and loud noises, do not strike sheep with canes, pipes or sticks and do not hold onto the wool while catching or restraining sheep. Use the minimum restraint needed to get the job done. The findings are also in line with the findings of William and Teri (2017) who had the view that trimming is required to prevent lameness and to improve animal comfort. Lloyd and Playford added that rams' horns need to be trimmed in order to; prevent ingrown horns damaging the face and eyes, prevent injury to other rams and handlers, help prevent flystrike, make rams easier to load and transport, and prevent rams catching their horns in fences, yards or trees. They further suggested that always ne careful not to remove too much hoof when paring. Overgrown feet may have blood vessels growing into the toe, so take care not to cause bleeding. Over trimming feet is painful for sheep and can lead to the formation of toe granulomas.

The findings of the research question three in Table 5 indicated that the entrepreneurial skills required for reproduction management practices in sheep husbandry by agricultural education students in tertiary institutions in Kano State are; know how to calculate/estimate time of lambing from breeding date, become familiar with reproductive tract diseases common to sheep, how the diseases spread and how they can be prevented, know how to perform basic first aid on a sheep/lamb, ability to recognize when an ewe is about to give birth, recognize a normal birth, recognize abnormal birthing (dystocia), be able to recognize and treat a retained placenta, know how to disinfect newborn's naval cord. know how to handle a newborn lamb safely, know how to protect yourself and your workers from zoonotic disease and develop a working relationship with a local veterinarian.

These findings are in line with the findings of Danie (n.d.). who revealed that most ewes can fall pregnant within two heat cycles, mating ratios of one ram to 40 - 50 ewes seem to be normal, injured rams cannot work effectively and must not stay with the ewes once signs of disease are observed, change in nutrition is an effective way of stimulating reproductive activity, lamb deaths can be reduced by better management during the lambing process, internal parasite infestations must be monitored especially during the wet season, the lamb is born without any immunity against diseases, the only immunity it will receive to protect it during the first two to three months of life will be obtained from the colostrum (first milk).

Conclusion

The findings of this study showed that all the 34 identified skills in this study were required by agricultural education students in tertiary institutions in Kano State for optimal success in sheep husbandry practices. Hence Lecturers in tertiary institution in Kano State are needed to

make use of the skills in training their students to enable the students acquire the entrepreneurial skills required in order to make them self-employed after graduation.

Recommendations

Based on the findings of the study, the following recommendations were made;

1. Lecturers for Agricultural Education Programme in tertiary institution in Kano State should focus on essential skills required for sheep husbandry that would help develop their students to become entrepreneurs.
2. Appropriate pedagogy should regularly be used by Lecturers of Agricultural Education Programme in tertiary institution in Kano State so as to ensure that the students clearly understand entrepreneurial skills, thus, making them active to exhibit the skills for the future.
3. Skill acquisition centres in Kano State should package the identified entrepreneurial skills for sheep husbandry into a programme and be used in training youths to make them self-reliance.

References

Bako, Y.A., Taiwo, A. A., Mohammed, S. R. & Olopade, O. J. (n.d.). *Skills acquisition and entrepreneurship development in Nigeria*. Department of Business Administration and management, The Federal Polytechnic Ilaro, Ogun State Nigeria. *ORCID:0000-0002-8940-2107.*

Danie, O.(n.d.). *Livestock handler training manuals module 2: production management in sheep.* Agri Connect (Pty) Ltd for Afrivet. Retrieved January 15, 2025 from co.za www.afrivet.co.z.

Danladi, S.A. &. Okoro, C. O. (2016). Entrepreneurship skill acquisition education in Nigeria's senior secondary school. a source of youths' empowerment. *Journal of Resourcefulness and Distinction, 13* (1) 1-9.

Dorothy, M. A. (n.d.). Relevance of career counselling in secondary school students' development of entrepreneurial skills for job creation and national development. *International Journal of Studies in Education, 16* (2), 1-9.

Khamis, M. & Alhassan M. G. (2020). Effect of entrepreneurial skills on small and medium scale enterprises performance: a study of registered businesses operating in Sabon Gari Market Kano. *International Journal of Advanced Academic Research (Social and Management Sciences) 6*(10), 82-96.

Lloyd, J. & Playford, M. (2013). *A producer's guide to sheep husbandry practices.* Meat & Livestock Australia Limited.

Rachmat, P. (2016). The influence of personality traits on the entrepreneurship of sheep farmers in Garut Regency. *American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS), 26* (3), 42-64.

Research Advisors. (2006). *Sample size table.* Retrieved on September 11, 2017 from http://research-advisors.com.

Richard, B. (2023). *Sustainable sheep production skills and knowledge list*. University of Maine Cooperative Extension. Retrieved 10th January, 2025, from https://extension.umaine.edu › livestock › sheep.

Livestock Producers (2013). *Sheep and goat production handbook.* United States Agency for International Development (USAID); Empowering New Generation to Improve Nutrition and Economic Opportunities (ENGINE) program. AID-663-A-11- 0001.

William P. S. & Teri, M. E. (2017). *Sheep Care Guides*. Maroon Circle: American Industry Sheep Association.

ASSESSING THE EFFECTIVENESS OF DIGITAL SKILLS INTEGRATION IN AGRICULTURAL EDUCATION FOR ECONOMIC DIVERSIFICATION IN DELTA STATE

IYEKE AGHOGHO PERCULIAR, Ph.D.
Department of Vocational & Technical Education
(Agricultural Education Unit),
Faculty of Education,
University of Delta, Agbor, Delta State
perculiar.iyeke@unidel.edu.ng

Abstract
Nigeria's dependence on crude oil revenue has amplified the urgency for economic diversification, with agriculture positioned as a viable alternative for inclusive growth and youth employment. However, the sector remains constrained by outdated, labour-intensive practices and low youth engagement. This study investigated the effectiveness of digital skills integration in agricultural education in Delta State as a strategy for modernizing the sector and enhancing students' readiness for agribusiness. Using a descriptive survey design, data were collected from 141 Agricultural Education students at Delta State University (DELSU) and the University of Delta (UNIDEL) through a validated questionnaire. Data were analysed using means, standard deviation, and independent t-tests at a 0.05 significance level. Findings revealed that while DELSU students reported significantly higher levels of digital skills integration, both institutions face common barriers including inadequate infrastructure, limited lecturer competence, high internet costs, and unreliable power supply. The study concludes that strengthening digital skills in agricultural curricula improves students' employability and agribusiness preparedness but requires systemic policy reforms, lecturer capacity building, and infrastructure investment. It therefore recommended curriculum review by the National Universities Commission, targeted lecturers' training by the Federal Ministry of Education, strategic funding by TETFund and partners, and affordable internet access through the National Communications Commission to bridge identified gaps.

Keywords: Digital agriculture, agritech, agricultural education, economic diversification, Delta State, Nigeria.

Introduction

Nigeria's economic structure has long been defined by an overdependence on crude oil exports, a condition that makes the country highly vulnerable to external shocks such as fluctuations in global oil prices and the volatility of international energy markets. This persistent vulnerability has strengthened the call for economic diversification, with agriculture recognized as a strategic sector for driving inclusive growth, ensuring food security, and creating employment opportunities (Opombo & Diawara, 2024; Bosch, 2025). Despite its immense potential, however, the Nigerian agricultural sector remains dominated by traditional, labour-intensive practices that often limit productivity and fail to appeal to the younger generation—particularly in regions like Delta State, which holds significant agricultural promise yet continues to grapple with high youth unemployment.

The emergence of the Fourth Industrial Revolution has transformed agriculture globally through the rise of digital technologies and smart farming systems. Digital

agriculture—or agritech—involves the use of information and communication technologies (ICTs), artificial intelligence (AI), the Internet of Things (IoT), drones, mobile applications, and geographic information systems (GIS) in various aspects of agricultural production, processing, and distribution (Fahmi & Mendrofa, 2023). These innovations enable real-time monitoring of crops and soil conditions, precision farming, data-driven decision-making, efficient resource management, and improved market access through mobile platforms (Woomer, *et al.*, 2025). By reducing labour intensity and boosting productivity and profitability, digital agriculture also has the potential to reshape how young people perceive farming—transforming it from outdated drudgery into an attractive, technology-driven career path (Abdullahi & Muhammad, 2024).

To fully harness these benefits, it is critical for agricultural education to adapt to these technological advancements. Embedding digital competencies into the agricultural curriculum is essential for preparing graduates who can thrive in a modern agribusiness environment and drive innovation in the sector (Sani, 2024; Ugwaka, 2025). In Nigeria, and especially in Delta State—with its vast agricultural resources and youthful population—tertiary agricultural education is delivered through universities, colleges of education, and polytechnics. Yet many of these institutions still operate with outdated curricula and teaching methods that do not align with the realities of a rapidly digitizing global agricultural sector (Ongachi & Belinder, 2025).

Although national frameworks such as the Nigeria e-Agriculture Strategy (2020) and the National Digital Economy Policy and Strategy (2020–2030) emphasize the integration of digital skills into agriculture and education systems, the actual implementation at the institutional level often remains fragmented, under-resourced, and poorly coordinated (Ujah-Ogbuagu, 2023; Degila, *et al.*, 2023; Amedu, *et al.*, 2023). As a result, students frequently graduate without the practical digital skills needed to take advantage of modern agritech opportunities, weakening their employability and capacity to launch innovative agribusinesses (Deji, *et al.*, 2024; Owolabi, *et al.*, 2023).

The challenges hindering digital skills integration in agricultural education in Delta State include limited access to reliable internet connectivity, inadequate digital infrastructure such as smart labs and e-learning tools, and insufficient opportunities for lecturers to update their digital competencies (Abiri, *et al.*, 2023; Ukpe, 2023). Many institutions continue to rely on conventional chalk-and-board teaching methods with minimal exposure to precision farming, data analytics, blockchain for traceability, mobile-based extension services, or other emerging technologies that define modern agriculture (Ndiomaluke, *et al.*, 2025). These systemic gaps restrict students' readiness to transition smoothly from academia to technology-driven agribusiness ventures—undermining the sector's potential to contribute to Nigeria's economic diversification agenda (Adisa, *et al.*, 2024).

Despite widespread recognition of digital agriculture's transformative potential, there remains a clear lack of empirical research that examines the actual status, effectiveness, and impact of digital skills integration within agricultural education in Delta State (Aja, *et al.*, 2024). This research gap limits policymakers, educators, and development partners from designing context-specific interventions that can bridge the divide between policy and practice.

Given these realities, this study aims to investigate the extent to which digital skills are integrated into agricultural education programs in Delta State, the key factors constraining effective implementation, and the implications for graduates' employability, entrepreneurship, and contribution to sustainable rural economic development. By generating practical evidence and actionable recommendations, this research will support curriculum reform, strategic investment, and capacity building—contributing to the broader goal of transforming

agriculture into a modern, technology-driven engine for youth empowerment and national economic diversification.

Purpose of the Study

The main purpose of this study is to assess the effectiveness of digital skills integration in agricultural education and its potential for economic diversification in Delta State. Specifically, the study seeks to:

i. evaluate the current level of digital skills taught in agricultural education programmes;
ii. examine the relationship between digital skills acquisition and students' readiness for agribusiness; and
iii. identify challenges faced in integrating digital technologies into agricultural curricula.

Research Questions

The following research questions guided the study:

1. What is the current status of digital skills integration in agricultural education in Delta State?
2. How do digital skills influence students' preparedness for agribusiness ventures?
3. What are the key barriers to integrating digital tools in agricultural education?

Hypotheses

The following hypotheses were tested at 0.05 alpha level:

Ho1: There is no significance difference between the mean ($\bar{x}$) ratings of students in both institutions on the current status of digital skills integration in agricultural education in Delta State.

Ho2: There is no significance difference between the mean ($\bar{x}$) ratings of students in both institutions on how digital skills influence their preparedness for agribusiness ventures.

Ho3: There is no significance difference between the mean ($\bar{x}$) ratings of students in both institutions on the key barriers to integrating digital tools in agricultural education.

Research Methodology

This study adopted a descriptive survey research design with a quantitative approach. The design is appropriate for assessing the effectiveness of digital skills integration in agricultural education for economic diversification in Delta State. The study's population comprised of all the Agricultural Education students in the 2 universities running Agricultural Education programme in Delta State. The total population of 141 students, made up of 74 students from Delta State University, Abraka, and 67 students from University of Delta, Agbor was used for the study. A well-developed questionnaire titled "Effectiveness of Digital Skills Integration in Agricultural Education Questionnaire (EDSIAEQ)" faced validated by three experts, and assessed with a split-half reliability method which yielded a Spearman-Brown coefficient of 0.82, was used to elicit responses from respondents. The data gathered from respondents were analyzed using the mean (X) and standard deviation. The t-test statistical tool was used to assess the differences between the responses of students in the two universities. All analyses will be conducted using Statistical Package for the Social Sciences (SPSS) version 26, and significance will be tested at the 0.05 alpha level**.**

Results

Table 1

Mean, Standard Deviation, and t-test Analysis of the Responses of Students on the Current Status of Digital Skills Integration in Agricultural Education in Delta State (n_1, Delta State University students = 107; n_2, University of Delta students = 60)

S/N	Item	DELSU		UNIDEL		t-cal	p-value	Remark
		$\mathbf{Mean_1}$	$\mathbf{SD_1}$	$\mathbf{Mean_2}$	$\mathbf{SD_2}$			

1	Curriculum includes digital skill training	3.84	0.95	3.21	1.07	2.412	0.019	Significant
2	Lecturers incorporate digital tools in teaching	3.65	0.88	3.18	0.91	2.034	0.047	Significant
3	Access to computer labs or ICT centers	3.42	1.05	2.96	1.11	1.649	0.105	Not significant
4	Use of e-learning platforms	3.25	1.02	3.10	0.98	0.581	0.564	Not significant
5	Formal training on digital tools	3.12	1.03	2.85	0.95	1.055	0.296	Not significant
6	Digital skills improve market research ability	4.01	0.83	3.42	0.96	2.546	0.014	Significant
7	Ability to develop agribusiness plan using digital tools	3.92	0.86	3.38	0.89	2.390	0.020	Significant
8	ICT exposure motivates agribusiness pursuit	3.88	0.89	3.54	0.91	1.463	0.149	Not significant
9	Confidence in using social media to promote agriculture	4.08	0.77	3.69	0.82	1.899	0.063	Not significant
10	Digital competency enhances employability	4.18	0.72	3.72	0.78	2.374	0.021	Significant
11	Insufficient digital infrastructure	4.03	0.90	4.09	0.85	-0.265	0.792	Not significant
12	Lecturers lack digital competence	3.96	0.89	4.02	0.87	-0.264	0.793	Not significant
13	Power supply issues hinder digital tools usage	4.25	0.82	4.38	0.79	-0.625	0.534	Not significant
14	High cost of internet data limits digital engagement	4.18	0.88	4.30	0.83	-0.543	0.589	Not significant
15	Little institutional support for ICT integration	3.88	0.92	4.01	0.87	-0.562	0.522	Not Significant

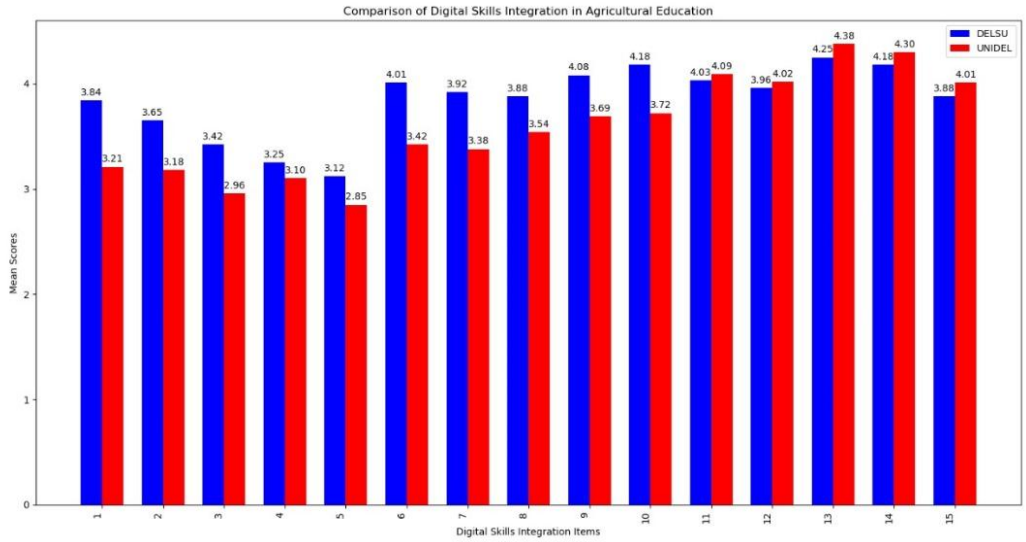


Figure I: Charts Showing the Responses of Students on the Current Status of Digital Skills Integration in Agricultural Education in Delta State

Table 2

Mean, Standard Deviation, and t-test Analysis of the Responses of Students on the Influence of Digital Skills on Students' Preparedness for Agribusiness Ventures (n_1, Delta State University students = 107; n_2, University of Delta students = 60)

S/N	Item	DELSU		UNIDEL		t-cal	p-value	Remark
		$\mathbf{Mean_1}$	$\mathbf{SD_1}$	$\mathbf{Mean_2}$	$\mathbf{SD_2}$			
1	Digital skills have improved my ability to conduct market research for agribusiness.	4.01	0.83	3.42	0.96	2.546	0.014	Significant
2	I can use digital tools to develop a basic agribusiness plan.	3.92	0.86	3.38	0.89	2.390	0.020	Significant
3	Exposure to ICT in agriculture has motivated me to pursue agribusiness.	3.88	0.89	3.54	0.91	1.463	0.149	Not significant
4	I feel confident using social media to promote agricultural products.	4.08	0.77	3.69	0.82	1.899	0.063	Not significant
5	My digital competency improves my employability in the agriculture sector.	4.18	0.72	3.72	0.78	2.374	0.021	Significant

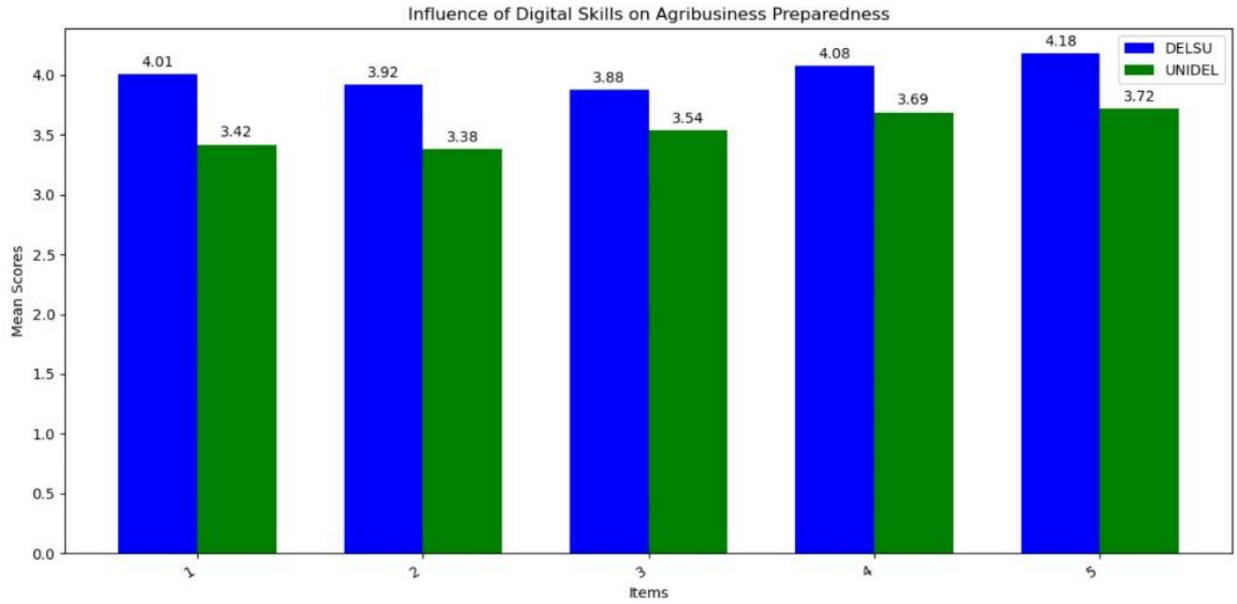


Figure II: Charts Showing the Responses of Students on the Influence of Digital Skills on Students' Preparedness for Agribusiness Ventures

Table 3

Mean, Standard Deviation, and t-test Analysis of the Responses of Students on the Barriers to Integration of Digital Tools in Agricultural Education (n_1, Delta State University students = 107; n_2, University of Delta students = 60)

S/N	Item	DELSU		UNIDEL		t-cal	p-value	Remark
		$\mathbf{Mean_1}$	$\mathbf{SD_1}$	$\mathbf{Mean_2}$	$\mathbf{SD_2}$			
1	There is insufficient access to digital infrastructure (computers, internet, etc.).	4.32	0.67	4.18	0.74	1.42	0.45	Not Significant
2	Many lecturers lack the digital competence to teach with technology.	4.16	0.72	3.89	0.81	2.35	0.18	Not Significant
3	Power supply issues hinder effective use of digital tools in education.	4.24	0.69	4.01	0.78	2.03	0.23	Not Significant
4	High cost of internet data limits student engagement with digital platforms.	4.36	0.64	4.19	0.70	1.64	0.33	Not Significant
5	There is little institutional support for integrating ICT in agricultural education.	4.11	0.71	3.78	0.85	2.73	0.11	Not Significant

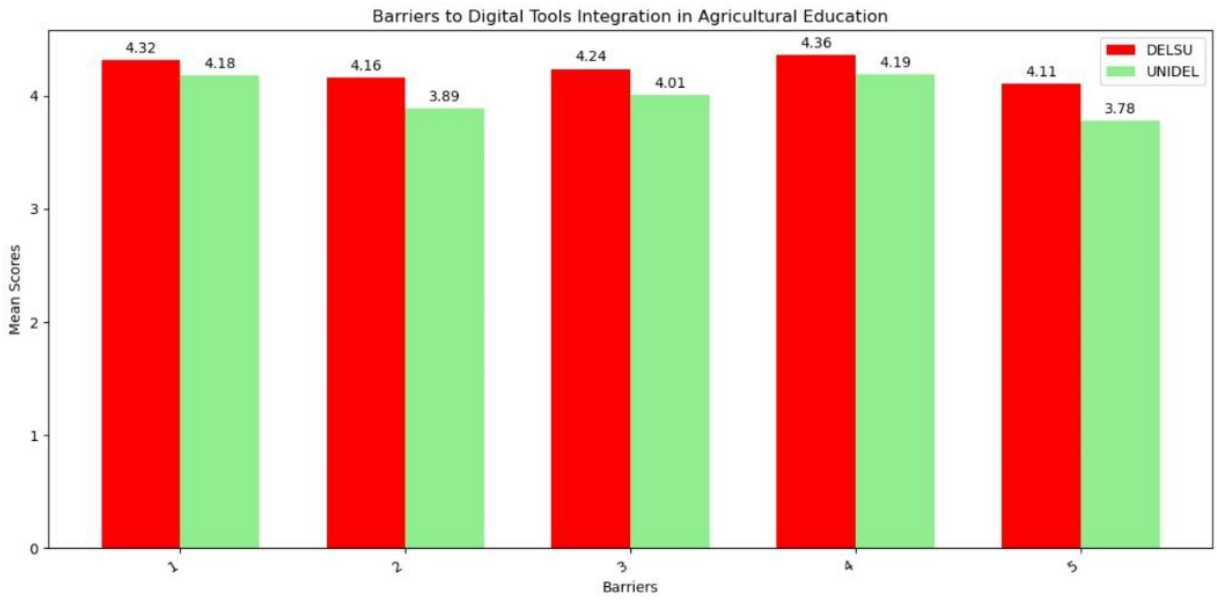


Figure III: Charts Showing the Responses of Students on the Barriers to Integration of Digital Tools in Agricultural Education

Discussion of Results

The findings from this study provide critical insights into the current status, influence, and barriers to the integration of digital skills in agricultural education across Delta State University (DELSU) and the University of Delta (UNIDEL).

The results from Table 1 indicate that both institutions are making efforts to integrate digital skills into their agricultural education curricula. However, DELSU students consistently reported higher mean scores across several indicators. Significant differences were observed in key areas such as the inclusion of digital skill training in the curriculum ($t = 2.412$, $p = 0.019$), lecturers' incorporation of digital tools in teaching ($t = 2.034$, $p = 0.047$), improvement of market research ability ($t = 2.546$, $p = 0.014$), the ability to develop agribusiness plans using digital tools ($t = 2.390$, $p = 0.020$), and the perception that digital competency enhances employability ($t = 2.374$, $p = 0.021$). These findings align with existing literature emphasizing the importance of digital skills in enhancing agricultural education outcomes and employability (Canton, 2021; Mkansi & Landman, 2021). The significantly higher responses from DELSU students suggest that the university may have more robust digital skill programs or better infrastructure than UNIDEL, which could be a critical factor for policymakers and institutional leaders to consider when planning curriculum improvements.

As presented in Table 2, digital skills positively influence students' preparedness for agribusiness ventures. Significant differences were found in students' ability to conduct market research ($t = 2.546$, $p = 0.014$), develop agribusiness plans ($t = 2.390$, $p = 0.020$), and enhance employability ($t = 2.374$, $p = 0.021$). These findings are consistent with reports by Izuogu, *et al.* (2025), which underscore the role of digital literacy in empowering students to access market information, develop viable agribusiness strategies, and become competitive in the agricultural sector. However, some factors such as motivation to pursue agribusiness and confidence in using social media for agricultural promotion did not show statistically significant differences between the two universities. This suggests that while digital skills are improving, there may be gaps in students' practical engagement and entrepreneurial mindset

development, a concern also noted by Afolabi, *et al.* (2024) in their assessment of digital education in Nigeria.

Table 3 highlights persistent barriers such as insufficient access to digital infrastructure, lecturers' limited digital competence, power supply issues, high internet costs, and minimal institutional support. Although these barriers were commonly reported by both universities, the differences were not statistically significant. This corroborates prior studies that have identified systemic challenges in Nigeria's educational and digital infrastructure, particularly in higher education settings (Okon, *et al.*, 2025; Oyekunle, *et al.*, 2024)). The lack of significant differences suggests that these barriers are widespread and require systemic interventions rather than institution-specific solutions. For instance, the high cost of internet data remains a formidable barrier to student engagement on digital platforms, echoing findings by the International Telecommunication Union (Sharp, 2024) that high data costs in sub-Saharan Africa continue to inhibit digital inclusion. Additionally, inadequate power supply—a long-standing infrastructural problem—remains a significant impediment to the effective deployment of digital tools in education.

Overall, the study reveals that digital skills integration in agricultural education is moderately effective, with notable positive impacts on student readiness for agribusiness. However, the persistence of infrastructural and systemic barriers limits the full realization of digital competencies' potential. The study thus underscores the need for targeted policy reforms, enhanced institutional support, and strategic investment in digital infrastructure to bridge the gaps identified.

Conclusion

This study assessed the effectiveness of digital skills integration in agricultural education in Delta State and its potential contribution to economic diversification. The findings revealed that while both Delta State University (DELSU) and the University of Delta (UNIDEL) have made progress in embedding digital skills within their agricultural curricula, DELSU students reported significantly higher levels of integration and perceived benefits in key areas such as market research, agribusiness planning, and employability.

However, the study also identified persistent barriers including inadequate digital infrastructure, insufficient lecturer digital competence, unreliable power supply, high internet costs, and weak institutional support. These barriers were commonly experienced across both universities, suggesting systemic challenges that hinder the full realization of digital agriculture's transformative potential.

In summary, the study concludes that digital skills integration supports students' preparedness for modern agribusiness and can contribute to Nigeria's broader goals of youth empowerment and economic diversification if systemic barriers are addressed through coordinated action.

Recommendations

In light of the findings, the following recommendations were proposed:

1. National Universities Commission (NUC) and University Senates should review and update agricultural education curricula to include practical digital skills such as precision farming, ICT applications, and agribusiness data analytics.
2. The Federal Ministry of Education, in collaboration with university management and professional development institutes, should organize regular training workshops to strengthen lecturers' capacity to teach modern digital tools.
3. The Federal and State Ministries of Education, the Tertiary Education Trust Fund (TETFund), and relevant development partners (e.g., international donors, NGOs)

should prioritize funding for modern digital infrastructure such as internet access, computer laboratories, and stable power supply.

4. The National Communications Commission (NCC) should work with telecommunications companies and university ICT units to reduce internet data costs for students and improve access to online learning resources.

References

Abdullahi, U., & Muhammad, S. I. (2024). A review on enhancing digital skills of rural dwellers through ICT: Bridging the digital divide. *Savannah Journal of Science and Engineering Technology*, *2*(1), 6-12.

Abiri, R., Rizan, N., Balasundram, S. K., Shahbazi, A. B., & Abdul-Hamid, H. (2023). Application of digital technologies for ensuring agricultural productivity. *Heliyon*, *9*(12).

Adisa, O., Ilugbusi, B. S., Adelekan, O. A., Asuzu, O. F., & Ndubuisi, N. L. (2024). A comprehensive review of redefining agricultural economics for sustainable development: Overcoming challenges and seizing opportunities in a changing world. *World Journal of Advanced Research and Reviews*, *21*(1), 2329-2341.

Afolabi, E. A., Omokore, D. F., Yusuf, H. O., & Oladimeji, Y. U. (2024). Through the lenses of actor-network approach-the digital transformation of Nigerian Agricultural Research Outreach Centre. *Journal of Agripreneurship and Sustainable Development*, *7*(3), 85-92.

Aja, O. O., Asiabaka, C. C., Ani, A. O., & Matthews-Njoku, E. C. (2024). Comparative study of the socioeconomic characteristics and digital literacy level of agricultural extension personnel in Imo and Ebonyi States, South-East, Nigeria. *Agricultural Sciences*, *15*(2), 230-245.

Amedu, A. A., Adeyemo, O. O., &Ojomu, T. Q. (2023). Digital agricultural extension and youth-led 'agripreneurship' in Ibadan North Local Government Area of Oyo State Nigeria. *International Journal of Research and Innovation in Social Science*, *7*(3), 1118-1124.

Babalola, S. S., & Genga, C. A. (2024). Managing digital transformation in African higher education institutions: Challenges and opportunities. *International Journal of E-Learning & Distance Education*, *39*(1), n1.

Balogun, A. L., Adebisi, N., Abubakar, I. R., Dano, U. L., & Tella, A. (2022). Digitalization for transformative urbanization, climate change adaptation, and sustainable farming in Africa: Trend, opportunities, and challenges. *Journal of Integrative Environmental Sciences*, *19*(1), 17-37.

Bosch, G. (2025). Unemployment–underemployment. In *The Elgar Companion to Decent Work and the Sustainable Development Goals* (pp. 139-151). Edward Elgar Publishing.

Boye, M., Ghafoor, A., Wudil, A. H., Usman, M., Prus, P., Fehér, A., & Sass, R. (2024). Youth engagement in agribusiness: perception, constraints, and skill training interventions in Africa: A systematic review. *Sustainability*, *16*(3), 1096.

Canton, H. (2021). Food and agriculture organization of the United Nations—FAO. In *The Europa directory of international organizations 2021* (pp. 297-305). Routledge.

Degila, J., Sodedji, F. A. K., Avakoudjo, H. G. G., Tahi, S. P. G., Houetohossou, S. C. A., Honfoga, A. C., ... &Assogbadjo, A. E. (2023). Digital agriculture policies and strategies for innovations in the agri-food systems—cases of five West African countries. *Sustainability*, *15*(12), 9192.

Deji, O. F., Famakinwa, M., Faniyi, E. O., Ojo, T. F., &Opayinka, A. O. (2024). Opportunities and challenges associated with ai-based digital technologies usage for agricultural extension services in nigeria. *Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development*, *24*(1).

Fahmi, F. Z., &Mendrofa, M. J. S. (2023). Rural transformation and the development of information and communication technologies: Evidence from Indonesia. *Technology in Society*, *75*, 102349.

Idike, A., Ukeje, I. O., Iwuala, H. O., Onele, J. C., Ekwunife, R. A., Nwachukwu, K., & Udu, O. (2019). The practice of inclusive representation in Nigeria bureaucracy: The federal character principle experience. *Cogent Social Sciences*, *5*(1), 1601545.

Izuogu, C. U., Njoku, L. C., Olaolu, M. O., Kadurumba, P. C., Azuamairo, G. C., &Agou, G. D. (2023). A review of the digitalization of agriculture in Nigeria. *Journal of Agricultural Extension*, *27*(2), 47-64.

Izuogu, C. U., Umeh, N. E., Musab, I., Ekweanya, N. M., Ankrah, D. A., Ebenehi, O., ... & Okorie, D. A. (2025). Determinants of Youth Participation in Rice Cultivation in South-Eastern Nigeria. *Journal of Agricultural Extension*, *29*(1), 37-46.

Mireku, D. O., Bervell, B., Dzamesi, P. D., & Nimo, E. B. (2024). A systematic review of students' support services provision in higher education (SSSPiHE) in sub-Saharan Africa. *Cogent Education*, *11*(1), 2351747.

Mkansi, M., & Landman, N. (2021). The future of work in Africa in the era of 4IR–The South African perspective. *Africa Journal of Management*, *7*(sup1), 17-30.

Ndiomaluke, C., Obi, C., Orajaka, U., Ejefobihi, U., & Percy, N. (2025). Economic diversification strategies for sustainable development in Nigeria. *Journal of Policy and Development Studies*, *18*(3), 1-23.

Okon, E. E., Egbai, O. O., & Uzoigwe, M. C. (2025). Managing school-based resources and secondary school effectiveness in Cross River State, Nigeria. *Journal of Public Administration, Policy and Governance Research*, *3*(2), 123-138.

Ongachi, W., &Belinder, I. (2025). Agricultural extension as a pathway to livelihood diversification and sustainable development in rural communities: a systematic review. *BMC Agriculture*, *1*(1), 6.

Opombo, H. M., & Diawara, F. (2024). Rural Economy Transformation and Education Policy in Sub-Saharan African. *Open Access Library Journal*, *11*(2), 1-17.

Osabohien, R. (2023). ICT adoption and youth employment in Nigeria's agricultural sector. *African Journal of Economic and Management Studies*, *15*(2), 177-194.

Owolabi, O. A., Adedeji, A. O., Aderounmu, B., Oku, A. R. O., & Ogunbiyi, T. (2023). Do Information and Communications Technology (ICT) and financial development contribute to economic diversification? Evidence from sub-Saharan Africa. *Journal of Economic Structures*, *12*(1), 5.

Oyekunle, O. B., Gbenga-Julius, O., & Adeeko, J. D. (2024). Unlocking Opportunities Exploring Success Factors and Challenges of Digital Integration in Vocational and Technical Education in Nigeria. *International Journal of Research and Innovation in Social Science*, *8*(12), 216-228.

Sani, M. A. (2024). Bridging the digital divide: Empowering Northern Nigeria through localized IT education and innovative technology.

Sharp, M. (2024). Revisiting the measurement of digital inclusion. *The World Bank Research Observer*, *39*(2), 289-318.

Ugwaka, K. A. (2025). Integrating digital agriculture into the undergraduate agricultural education programmes in Nigerian universities for vocational development. *Unizik Journal of Educational Research, Science and Vocational Studies*, *2*(1).

Ujah-Ogbuagu, B. C. (2023). An Assessment of State of Digital Economy Development in Nigeria: A Survey. In *International Conference on Communication and E-Systems For Economic Stability| CeSES* (p. 380).

Walimbwa, M. (2023). Digital Transformation of Higher Education and Twenty-First-Century Skilling in Sub-Saharan Africa: Potentials and Challenges. *Higher Education in Sub-Saharan Africa in the 21st Century: Pedagogy, Research and Community-Engagement*, 313-325.

Woomer, P. L., Lewis, S., Mulei, W. E. L. I. S. S. A., Adenmosum, A., Dashiell, K., & Sanginga, N. (2025). African Agricultural Transformation: Perspectives from the International Institute of Tropical Agriculture.

INFLUENCE OF COLLECTION TIME ON NUTRIENTS AND MICROBIAL LOADS OF SOME FROZEN MARINE FISH SPECIES SOLD IN BICHI LOCAL GOVERNMENT AREA OF KANO STATE, NIGERIA

KASIM LAWAL IBRAHIM
talk2klawal@gmail.com & 08066969364
DEPARTMENT OF AGRICULTURAL EDUCATION
FEDERAL COLLEGE OF EDUCATION (TECHNICAL) BICHI, KANO STATE.
NIGERIA

ABSTRACT

This study was carried to evaluate the influence of collection time on nutritional compositions and microbial loads of some frozen marine fish species; *Clupea harengus*, *Scomber scombrus* and *Trachurus trachurus* sold in Bichi local government area of Kano State, Nigeria. A total of 27 samples comprising of nine of each species were collected from the sampling station. The first collection was done upon the arrival of the stocks, the second collection was done four days after while the third collection was done when their stocks were about to finish. The samples were analyzed for proximate compositions, minerals, fatty acids, and microbial load. Results indicated that the highest crude protein content, 22.66% was recorded in *S. scombrus* from second collection. All the proximate composition parameters were affected by the species and collection time. *S. scombrus* had the highest calcium content, 1.40 mg/kg from second collection. All the mineral parameters were affected by the species except potassium, while collection time only affected potassium and iron. The highest free fatty acids content, 2.14% was observed in *T. trachurus* from third collection. *S. scombrus* recorded the highest *Salmonella spp.* count of 3.67 x 10^6cfu/g from third collection, *Salmonella sp* and total coliform counts were affected by the species while collection time affected all the microbial parameters except mold. These values were within the range for of safe and nutritionally balanced fish products. The study recommended *S. scrombus* as the best for human consumption due to its higher protein, least lipid and superior mineral composition.

Keywords: Minerals, Microbial Loads, Frozen, Marine Fish, Nutritional

Introduction

The widely acceptability of fish by a very diverse group of people irrespective of religious beliefs, socioeconomic backgrounds and age group makes fish an important source of animal protein in the world. These attributes plus its affordability and availability makes fish a valuable and affordable source of animal protein, particularly in developing nations (Dauda *et al.,* 2020). Fish as a rich source of protein, it has different forms of simple proteins with different essential amino acids, fats and traces of vitamin B Complex and other non-protein nitrogenous forms **(**Brasky *et al.,* 2010**).** Fish consumption is therefore, linked to the reduction of risks of various types of diseases and improvement of neurological development and other health related issues (Hellberg *et al.,* 2012). Furthermore, fish comprises of proteins and fats (macronutrient) and vitamins and minerals (micronutrient) that are required for good nutrition, thereby effectively contributing to food and nutrition security as an accompaniment to rice-based diets in Asia and maize and cassava-based diets in Africa (Glover-Amengor *et al.,* 2012).

Understanding the proximate composition of fish is critical for consumers as well as managers to ensure that they meet the requirements of food regulations and commercial

specifications. Also, proximate composition is a good indicator of physiology which is needed for routine analysis of fishes (Tsegay *et al.,* 2016). Generally, fish is 70 to 80% water, 20 to 30% protein, and 2 to 12% fat. Minerals in fish, such as iron, calcium, zinc, iodine from marine fish, phosphorus, and selenium, are especially concentrated in the bones. Fish is thus an excellent source of minerals, especially when eaten whole, including the bones (Glover-Amengor *et al.,* 2012). On the other hand, in different environmental situations, the composition of the fish may vary due to variances in water quality, feeding conditions, sex, maturation status, and catch condition (Palani *et al.,* 2014). Fish as a protein source, is highly perishable and contains a high level of free amino acids, which are metabolized by microbes to produce ammonia, biogenic amines like putrescine, histamine, cadaverine, organic acids, ketones, and sulphur compounds (Ezemba *et al.,* 2017; Ekanem and Udoma, 2021). It requires good preservation methods to ensure it retains its quality as the major goal of food technologists and fish merchants is to preserve and market frozen fish products in a high-quality and safe manner (Speranza *et al.,* 2021).

Due to the diverse nature of the marine environment, there's a significant chance of infection of fish caught there by microbes and this necessitates that immediately fish is caught, it must be stored in a good manner (such as freezer) before entering the supply chain in order to extend its shelf life and makes it accessible over long distances and period of time. For this reason, freezing is a helpful method for preserving fish and other seafood products without significantly sacrificing their quality (Baoguo *et al.,* 2020). Freezing preserves food for a longer duration of time by inhibiting the growth and proliferation of bacteria that cause food spoilage and foodborne illness, as well as inhibiting the food's own enzyme activity, which would otherwise cause the food to rot. The majority of germs do not multiply at freezing temperatures. Furthermore, germs require water to develop, and freezing converts the available water into solid ice crystals. Freezing is a common practice in the meat, fish, and other animal protein-based industries because it preserves quality for an extended period of time and provides several benefits such as minimal changes in product dimensions and minimal deterioration in colour, flavour, and texture (USDA Food Safety Information, 2013).

It is generally recognized that fish can harbour human harmful bacteria, particularly the coliform group (Adedeji *et al.,* 2012; Ekanem and Udoma, 2021). Microbiological quality is important to public health since it directly affects fish deterioration and is a cause of food poisoning. Bacteriological risks that cause illnesses and poor health are directly tied to food safety concerns with animal proteins obtained from marketed food, such as fish, fisheries products, meat, and meat products. This raises a burning question for all consumers dealing with a high-risk item in terms of pathogenic bacteria contamination, which poses a food safety risk (Ekanem and Udoma, 2021). The majority of frozen fish marketed in Bichi Metropolitan Area, Kano State, are exposed to dust and contamination, which fosters the growth of germs due to their ubiquity, hence increasing pathogen transmission and prevalence. Furthermore, poor personal hygiene, such as failing to wash one's hands after handling contaminated objects, promotes pathogen contamination of frozen fish. There is uncertainty whether fish stocks were able to maintain their quality between when they arrived in the cold room and when they are exhausted, therefore no information on quality change over the time the fish is sold. It is therefore pertinent to evaluate the nutritional and mineral composition as well as the microbiological load of three (3) imported frozen fish most commonly sold in Bichi Metropolitan Area, Kano State at different collection times.

Materials and Methods

Study area

Bichi town is the Headquarter of Bichi Local Government Area in Kano State, Nigeria. It is ranked to be second in population in Kano State with total of about 277,099 people (NPC,

2006). It has a total area of 612 km^2 and it lies between Coordinates: 12°14′03″N 8°14′28″E (Abdullahi *et al.,* 2020).

Sampling Size and Procedure

Three most commonly sold frozen marine fish in the study areas were used. A total of 27 samples comprising nine Atlantic herring (*Clupea harengus*), nine Atlantic mackerel (*Scomber scombrus*) and nine Atlantic horse mackerel (*Trachurus trachurus*) were purchased from the major frozen fish cold-room in Bichi Local Government Area. The first sample collection was done upon the arrival of the stocks/products, the second collection was done four days after the first collection and the third collection was done when their stocks were about to finish (7 days from arrival). The fish samples were collected into a sterile tinfoil paper individually and immediately transported in an ice cooler/cold flask to retain the freshness, to Umaru Musa Yar'adua University, Katsina (UMYU) at the Biochemistry laboratory and Microbiology laboratory for analysis of proximate compositions and microbial load respectively.

Nutritional Composition Analyses

Proximate analysis, the moisture content, crude protein, crude lipid and ash content of fish sample were analyzed using the method of analyses by Association of Official Analytical Chemists (AOAC, 2016).

Free Fatty Acids Analysis

A modified method of AOAC Official Method 940.28 Fatty Acids (Free) in Crude and Refined Oils Titration Method (AOAC, 2012)

Mineral Analysis

Mineral contents were determined using atomic absorption spectrometer (AAS) and flame photometer analysis (Ismaniza *et al.,* 2012).

Microbiological Analysis

Microbial analysis was determined using standard microbiological procedures (Alkuraieef *et al.,* 2021; Arendrup *et al.,* 2021; Cheesbrough, 2005).

Data Analysis

Data was analyzed using descriptive statistics (mean ± standard deviation). The data was subj ected to normality and homogeneity of variance tests, after which a two-way analysis of variance (ANOVA) was used to compare the fish species for each parameter, also to compare the collection times for each parameter at 95% level of probability ($P < 0.05$). Whenever a significant difference was observed Turkey' HSD test was used to separate the different means using IBM SPSS Version 23.

Results

The results of the proximate composition of the three frozen marine fish species collected at different times are shown in Table 1, highest moisture (77.69 ± 0.09%) was observed in *C. harengus* from third collection. The moisture was significantly higher in *C. harengus* ($P<0.05$) compared to other species. The difference in moisture due to collection time was also significant with the highest at 3rd collection time. The total ash of (2.91 ± 0.07%) recorded in *T. trachurus* from third collection was the highest. The ash was significantly higher ($P<0.05$) in *T. trachurus* than other species. It was significantly different among ($P<0.05$) the collection times with the highest at 3rd collection time. The highest crude protein, 22.66 ± 0.14% was recorded in *S. scombrus* from second collection. Crude protein was significantly higher in *S. scombrus* compared to other species ($P<0.05$). There was a significant difference ($P<0.05$) in crude protein due to collection time, with at the second collection time. The highest crude lipid, 5.94 ± 0.04% was recorded in *C. harengus* from second collection, it was significantly higher in *C. harengus* than other species. It was

significantly (P<0.05) higher at the third collection time. The highest free fatty acids, 2.14 ± 0.03 was observed in *T. trachurus* from first collection, while the least, 0.72 ± .030 was recorded in *C. harengus* from third collection. Free fatty acids was higher significantly in *T. trachurus* compared to other species. The difference in free fatty acids due to collection was significant (P<0.05).

The results of the mineral composition of fish at different times is shown in Table 2, highest Na (1.98 ± 0.67 mg/kg) was observed in *C. harengus* from second collection, it was significantly higher in *C. harengus* (P<0.05) compared to other species but the difference in Na due to collection time was not significant (P>0.05). The Ca of 1.40 ± 0.61 mg/kg recorded in *S. scombrus* from second collection was the highest, it was significantly higher (P<0.05) in *S. scombrus* than the other species but it was not different significantly (P>0.05) among the collection times. The highest K, 0.76 ± 0.14 mg/kg was recorded in *C. harengus* from second collection, it was was not significant different (P>0.05) among the species but there was a significant difference (P<0.05) due to collection. The highest Fe, 1.14 ± 0.05 mg/kg was recorded in *S. scombrus* from first collection, Fe was significantly higher in *S. scombrus* than other species (P<0.05). It was significantly different due to collection. The highest Mn, 0.36 ± 0.05 mg/kg was recorded in *T. trachurus* from first collection, Mn was significantly higher in *T. trachurus* than other species (P<0.05) but it was not significantly difference (P>0.05) due to collection time.

The results of microbial population of the fish species collected from Bichi station is shown in Table 3, highest Salmonella (3.67 ± 1.53 × 10^6 cfu/g) was observed in *S. scombrus* from third collection, it was significantly different (P<0.05) from other species. The difference in *Salmonella* due to collection time was also significant (P<0.05), with the highest at 3rd collection. The *E. coli* was not significantly different among the species (P>0.05) but it was different significantly (P<0.05) due to the collection time. The highest total coliform count, 5.00 ± 1.00 × 10^6 cfu/g was recorded in *C. harengus* from first collection, it was significantly higher in *C. harengus* than other species (P<0.05) and there was a significant difference (P<0.05) due to collection. The mold was not different significantly among the species (P>0.05) and among the collection time.

Table 1: Proximate and Free Fatty Acids Compositions of the Three Frozen Marine Fish Species Collected at Different Times from Bichi Station

Bichi Station Sample Collection					Two-way ANOVA		
Parameters (%)	**Collection**	***C. harengus***	***S. scombrus***	***T. trachurus***	**Species (P value)**	**Collection (P value)**	**Species * Collection (P value)**
Moisture	**1st**	$75.56 \pm 0.04^{B,a}$	71.10 ± 0.01^{b}	71.18 ± 0.02^{c}	0.000	0.000	0.000
	2nd	73.51 ± 0.04^{C}	70.83 ± 0.11	68.94 ± 0.04			
	3rd	77.69 ± 0.09^{A}	73.35 ± 0.21	69.29 ± 0.04			
Crude Protein	**1st**	$14.85 \pm 0.02^{C,c}$	20.19 ± 0.05^{a}	18.29 ± 0.06^{b}	0.000	0.000	0.000
	2nd	15.71 ± 0.04^{A}	22.66 ± 0.14	21.92 ± 0.05			
	3rd	15.27 ± 0.05^{B}	19.14 ± 0.10	19.87 ± 0.11			
Crude Lipid	**1st**	$4.84 \pm 0.04^{A,a}$	4.44 ± 0.11^{b}	5.22 ± 0.02^{a}	0.000	0.000	0.000
	2nd	5.94 ± 0.04^{B}	3.92 ± 0.09	4.38 ± 0.03			
	3rd	3.32 ± 0.07^{C}	3.86 ± 0.12	4.48 ± 0.03			
Total ash	**1st**	$2.25 \pm 0.02^{B,b}$	2.32 ± 0.04^{b}	2.81 ± 0.04^{a}	0.000	0.000	0.000
	2nd	2.25 ± 0.03^{C}	1.90 ± 0.08	2.45 ± 0.03			
	3rd	2.48 ± 0.19^{A}	2.71 ± 0.13	2.91 ± 0.07			
Carbohydrate	**1st**	$2.51 \pm 0.11^{A,b}$	1.94 ± 0.12^{c}	2.50 ± 0.03^{a}	0.000	0.002	0.000
	2nd	2.52 ± 0.13^{B}	0.69 ± 0.14	2.31 ± 0.02			
	3rd	1.49 ± 0.43^{B}	1.09 ± 0.48	3.45 ± 0.23			
Free fatty acid	**1st**	$0.90 \pm 0.07^{B,c}$	1.17 ± 0.12^{b}	2.14 ± 0.03^{a}	0.000	0.000	0.000
	2nd	1.15 ± 0.03^{A}	1.43 ± 0.09	2.04 ± 0.02			
	3rd	$0.72 \pm .030^{C}$	1.19 ± 0.03	1.92 ± 0.04			

*Values are presented as the means ± standard deviation

*Different small letters as superscripts across the rows indicate significant differences ($P < 0.05$) among the fish species.

*Different capital letters as superscripts within the column for each parameters indicate significant differences ($P < 0.05$) among the stations

Key: 1st – First Collection

2nd – Second Collection

3rd – Third Collection

Table 2: Minerals Compositions of Three Frozen Marine Fish Species Collected at Different Time From Bichi Station

Bichi Station Sample Collection					Two-way ANOVA		
Parameters (mg/kg)	**Collection**	***C. harengus***	***S. scombrus***	***T. trachurus***	**Species (P value)**	**Collection (P value)**	**Species * Collection (P value)**
Sodium (Na)	**1st**	$1.45 \pm 0.51^{A,a}$	0.36 ± 0.02^{b}	0.46 ± 0.03^{b}	0.000	0.406	0.882
	2nd	1.98 ± 0.67^{A}	0.45 ± 0.09	0.59 ± 0.09			
	3rd	1.65 ± 0.89^{A}	0.35 ± 0.03	0.46 ± 0.03			
Calcium (Ca)	**1st**	$0.11 \pm 0.01^{A,b}$	1.38 ± 0.59^{a}	0.13 ± 0.03^{a}	0.000	0.529	0.639
	2nd	0.12 ± 0.01^{A}	1.40 ± 0.61	0.14 ± 0.04			
	3rd	0.12 ± 0.02^{A}	0.96 ± 0.39	0.13 ± 0.03			
Potassium (K)	**1st**	$0.60 \pm 0.23^{B,a}$	0.47 ± 0.02^{a}	0.48 ± 0.11^{a}	0.248	0.013	0.985
	2nd	0.76 ± 0.14^{A}	0.63 ± 0.17	0.72 ± 0.06			
	3rd	0.55 ± 0.25^{B}	0.46 ± 0.04	0.48 ± 0.11			
Iron (Fe)	**1st**	$0.65 \pm 0.04^{A,b}$	1.14 ± 0.05^{a}	0.81 ± 0.03^{b}	0.000	0.000	0.000
	2nd	0.56 ± 0.06^{B}	1.07 ± 0.04	0.34 ± 0.03			
	3rd	0.82 ± 0.06^{C}	0.25 ± 0.04	0.74 ± 0.03			
Manganese (Mn)	**1st**	$0.28 \pm 0.02^{A,b}$	0.16 ± 0.03^{b}	0.36 ± 0.05^{a}	0.000	0.256	0.000
	2nd	0.25 ± 0.03^{A}	0.23 ± 0.03	0.35 ± 0.03			
	3rd	0.16 ± 0.04^{A}	0.26 ± 0.04	0.33 ± 0.03			

*Values are presented as the means ± standard deviation

*Different small letters as superscripts across the rows indicate significant differences ($P < 0.05$) among the fish species.

*Different capital letters as superscripts within the column for each parameters indicate significant differences ($P < 0.05$) among collection time

Key: 1st – First Collection

2nd – Second Collection

3rd – Third Collection

Table 3: Microbial Population of Three Frozen Marine Fish Species Collected at Different Time From Bichi Station

Bichi Station Sample Collection					Two-way ANOVA		
Parameters ($x10^6$cfu/g)	**Collection**	***C. harengus***	***S. scombrus***	***T. trachurus***	**Species (P value)**	**Collection (P value)**	**Species * Collection (P value)**
Salmonella spp	**1st**	$0.67 \pm 0.58^{AB,b}$	1.33 ± 0.58^{a}	1.33 ± 0.58^{ab}	0.010	0.044	0.037
	2nd	0.33 ± 0.58^{B}	1.00 ± 1.00	1.33 ± 0.58			
	3rd	1.00 ± 0.00^{A}	3.67 ± 1.53	1.00 ± 1.00			
E. coli	**1st**	$2.33 \pm 1.53^{A,a}$	3.67 ± 1.53^{a}	1.67 ± 1.53^{a}	0.387	0.039	0.083
	2nd	2.00 ± 1.00^{B}	0.33 ± 0.58	1.67 ± 0.53			
	3rd	1.33 ± 0.58^{B}	2.00 ± 1.00	0.67 ± 0.58			
Total coliform	**1st**	$5.00 \pm 1.00^{A,a}$	4.00 ± 1.73^{b}	1.00 ± 1.00^{b}	0.002	0.022	0.138
	2nd	3.00 ± 1.00^{AB}	2.00 ± 1.73	1.00 ± 1.73			
	3rd	3.00 ± 1.00^{B}	0.33 ± 0.58	1.33 ± 1.15			
Mold	**1st**	$6.33 \pm 2.08^{A,a}$	3.66 ± 2.08^{a}	4.67 ± 3.79^{a}	0.298	0.577	0.308
	2nd	4.00 ± 1.00^{A}	4.67 ± 0.58	3.00 ± 1.00			
	3rd	4.33 ± 1.53^{A}	6.33 ± 2.31	3.00 ± 2.00			

*Values are presented as the means ± standard deviation

*Different small letters as superscripts across the rows indicate significant differences ($P < 0.05$) among the fish species.

*Different capital letters as superscripts within the column for each parameters indicate significant differences ($P < 0.05$) among the stations

Key: 1st – First Collection
2nd – Second Collection
3rd – Third Collection

Discussion

Fish has been a food source for human worldwide from time immemorial, especially as an inexpensive source of animal protein. Therefore, the proximate compositions of the fish species help to provide important nutritional profile (Nurnadia *et al.,* 2011). Several researchers have reported proximate composition of different fish species and documented differences due to species (Abubakar, 2016; Babalola *et al.*, 2011; Bello *et al.,* 2019; Elaigwu, 2019; Mohammad *et al.,* 2019; Palani *et al.,* 2014). In this study all the proximate composition parameters were affected by both the species and collection time. For instance, highest amount of moisture was reported in *C. harengus* which was significantly higher than that of *S. scombrus* and *T. trachurus*. This is similar to study of Bello *et al.,* (2019) who studied on *C. harengus, T. trachurus, S. scombrus* and *M. undulates*. *T. trachurus* had reported higher, lipid, total ash and estimated carbohydrate. This observation may be due to difference in species of fish experimented. This is in line with observation of Elaigwu, (2019) who reported differences in proximate composition of fresh water fish species (*Schilbe mystus, Bagrus bayad, Oreochromis niloticus, Clarias anguillaris* and *Petrocephalus bane bane*).

The result also is line with the study of Babalola *et al.,* (2011) who reported differences in proximate composition of marine and fresh water fish species (*S. scombrus, T. trachurus, S. aurita, M. furnieri* and *C. gariepinus*). In contradictory to this study Omolara and Omotayo, (2009) reported differences in proximate compositions of marine water fish species with *T. trachurus* having higher moisture values over *S. aurita*. They also reported *S. scombrus* to have higher protein content over *T. trachurus and C. harengus* (Omolara and Omotayo, 2009). The differences due to collection times in the station might be due to handling and the differences in storing between the source and the cold room. Aubourg *et al.* (2012) earler noted that the duration of freezing storage and different methods of handling might affect proximate composition values. The biochemical composition of fishes could greatly affect the postharvest processes and storage. Understanding this may assist in determining the suitability of different species to specific processing and storage methods (Malik *et al.,* 2021). Protein is the major nutrients in fish, but composition varies depending on age, sex, environment and seasonal migration of which their percentage level helps to define the nutritional status of a particular organism (Aberoumand and Pourshafi, 2010; Ahmed *et al.,* 2022). Generally, the proximate compositions of these fish species studied are within the recommended and safety level for consumption.

Minerals play important role in maintaining body functions because they maintain acid base balance, and help blood formation (hemoglobin formation). They also control the water balance in the body, help bones formation and teeth structure, and catalyze many metabolic reactions (Njinkoue *et al.,* 2016). All aquatic animals require minerals for their vital physiological and biochemical functions and to maintain their normal life processes (Lall and Kaushik, 2021). Several researchers have reported mineral compositions of different fish species and documented differences due to species (Achionye-Nzeh *et al.,* 2011; Guizani and Moujahed, 2015; Haizhou *et al.,* 2022; Okpanachi *et al.,* 2018; Stanton *et al.,* 2020; Tenyang *et al.,* 2014). In this study all the mineral compositions parameters were affected by the species except potassium while collection time affected only potassium and iron. For instance, highest amount of Sodium (Na) was reported in *C. harengus* which was significantly higher than that of *S. scombrus* and *T. trachurus*. Furthermore, the highest amount of Calcium (Ca) was reported in *S. scombrus* which was significantly higher than that of *T. trachurus* and *C.*

harengus and the highest amount of Manganese (Mn) was reported in *T. trachurus* which was significantly higher than that of *S. scombrus* and *C. harengus*. This is similar to the observation of Stanton *et al.* (2020) who studied *C. harengus, C. aper* and *M. poutassou* and that of Achionye-Nzeh *et al.* (2011) who studied *S. scombrus, T. trachurus, K. Pelamis* and *G. lineates. C. harengus* and *T. trachurus* had the highest Sodium (Na) and Manganese (Mn) contents and this observation may be due to differences in species of fish studied. The mineral compositions in this study varied significantly among the species this may be due to the fact that variations in concentrations of these mineral elements varies from one species of fish to another and also due to the chemical forms of the elements and their concentrations in the local environment (Babalola *et al.,* 2011). Expectedly, all fishes absorb minerals not only from their diets but also from the surrounding aquatic environment via their gills and skin (Nurnadia *et al.,* 2013).

Free fatty acids play important roles as a source of energy for most body tissues and their functions in energy transport within the body are well established (Binienda *et al.,* 2013). Free fatty acids also play important role in oxidative stress following cell membrane depolarization (Binienda *et al.,* 2013; Kimura *et al.,* 2019). Many researchers have reported free fatty acids composition of different fish species and documented differences due to species (Abubakar, 2016; Fawole *et al.,* 2018; Koppers *et al.,* 2010; Mervat, 2008). In this study free fatty acids composition were affected by the species and the collection time. For instance, highest amount of free fatty acids was reported in *T. trachurus* which was different significantly higher than that of *S. scombrus* and *C. harengus*. This is similar to observation of Abubakar, (2016) who studied *C. harengus, T. trachurus* and *S. pilchardus* where *T. trachurus* reported higher free fatty acids compositions. This observation may be due to difference in species of fish studied. This is in line with observation of Fawole *et al.* (2018) who also reported differences in free fatty acids composition of frozen marine fish species (*Sardinella* spp. and *M. poutassou*). Mervat, (2008) also reported difference in free fatty acids composition of frozen marine fish species (*C. harengus, T. trachurus* and *S. scombrus*). The differences observed in the free fatty acids composition values among the collection times may be due to the duration of freezing storage and methods of handling (Alsuhaibani *et al.,* 2020; Aubourg *et al.,* 2012; Fawole *et al.,* 2018). However, the free fatty acid in the samples studied were within the FAO recommended level of 2.5% for consumption (FAO, 2014), and is in line with International Fish Oils Standard (IFOS) who reported a range of 1% to 7% as standard (IFOS, 2011). The free fatty acids compositions of these fish species studied are within the acceptable and safety limits, therefore, they are safe for consumption.

The basic nutrient of protein in fish that is so important in man's diet also attracted microorganisms for their growth and multiplication (Silvia *et al.,* 2020). The association of these microorganisms in fishes depends on the environment and their proliferation due to inadequate storage facilities (Olagbemide and Akharaiyi, 2021). Many researchers have reported microbial load of different fish species and documented differences due to species (Adegunwa *et al.,* 2013; Adeparusi *et al.,* 2019; Ali *et al.,* 2020; Bello *et al.,* 2019; Daniel *et al.,* 2013; Taiwo *et al.,* 2017). In this study *Salmonella sp* and total coliform counts were affected by both the species and collection time, while *E. coli* was only influenced by the collection time. For instance, highest amount of microbial load was reported in *C. harengus* which was significantly higher than that of *T. trachurus* and *S. scombrus.* This is similar to observation of Daniel *et al.* (2013) who studied bacteria load on *T. trachurus, S. scombrus, C. gariepinus, E. fimbriata* and *P. croaker*. *T. trachurus* had the highest *Salmonella spp* count, *S.*

scombrus had the highest *E. coli* count and *C. gariepinus* had the highest total coliform and mold count, this observation may be due to differences in species of fish experimented and difference in methods of handling. This is in line with observation of Adeparusi *et al.* (2019) who also reported difference in bacteria loads of marine water fish species (*C. harengus, S. scombrus and M. poutassou*). Taiwo *et al.* (2017) also reported difference in bacteria loads of marine water fish species *T. trachurus, S. scombrus, L. crocea, G. chalcogrammus and O. niloticus*.

The variations in the bacterial loads for all the three fish species studied from is an indication that handling and perseveration methods employed from the source and the station might be different. This is supported by Olutimehin *et al.* (2019) who stated that handling and preservation methods have effects on the level of microbial loads in fish. The microbial load recorded in this study did not exceed the recommended limit of $x10^6$ to 10^7cfu/g of bacteria load (Gilbert *et al.*, 2000; NAFDAC, 2015; Rubaijaniza *et al.*, 2021). This could be due to the fact that the fishes received good preservation method and handling by the fish vendors at the cold room in Bichi town (Olutimehin *et al.*, 2019; Rubaijaniza *et al.*, 2021). Generally, it has been observed that appropriate methods of handling of fish during preservation reduces microbial loads in the final products (Huong, 2014). The significant variation noted between individual fish species in this study could be due to the fact that the fish were caught at random and they have differences in method of preservation, freezing/storage, handling, variation in sex, age, and environment (Burke, 2011). However, the microbial loads found in these fish species are within the safety and recommend ed level which cause no harm to human when consumed.

Conclusion

S. scrombus had the highest crude protein and the least lipid, it also had highest calcium, potassium and iron. T. trachurus appeared better in terms of Salmonella sp load, the total coliform count was similar between the *S. scrombus* and *T. trachurus.* While the proximate and mineral contents tended to reduce with collection time, the microbial load tended towards increase with the collection times. However, the proximate composition of all the examined fishes irrespective of the collection times showed that they contain all the required nutrients within the recommended limit and thus suitable for human consumption, though significant difference was observed in some of the parameters. The current investigation also revealed the rate of contamination by three pathogens in marine fish sold in Bichi for the first time. These results demonstrated that the pathogenic bacteria load of the studied marine fish was fairly high though not beyond the safe limit for consumption. Overall, *S. scrombus* tended to be the best in the study area followed by *T. trachurus.*

References

Abdullahi, B. N., Yeboah, F. K., Ahmed, N., and Muhammad, I. U. (2020). Profitability of Small-Scale Maize Production in Nigeria: A Case Study of Bichi Local Government, Kano State-Nigeria. *European Journal of Agriculture and Food Sciences*, *2*(5), 11-20.

Aberoumand, A., and Pourshafi, K. (2010). Chemical and proximate composition properties of different fish species obtained from Iran. *World Journal of Fish Marine Sciences*, *2*(1), 237 – 239.

Abubakar, R. (2016). Physical, Chemical and Quality Indices of Three Imported Frozen Marine Fish Species Sold in Zaria, Nigeria. *MSc. Dissertation. Department of*

Biological Sciences, Faculty of Science, Ahmadu Bello University, Zaria, Nigeria, 1-51.

Achionye-Nzeh, C. G., Adedoyin, O. M., Oyebanji, S., and Mohammed, M. O. (2011). Mineral composition of some marine and freshwater fishes. *Agriculture and Biology Journal of North America*, *2*(7), 1113-1116.

Adegunwa, M. O., Adebowale, A. A., Olisa, Z. G., and Bakare, H. A. (2013). Chemical and microbiological qualities of smoked herring (sardinella eba, valenciennes 1847) in Odeda, Ogun state, Nigeria. *International Journal of Microbiology*, *1*(5), 85-87.

Adeparusi, E. O., Adejuyigbe, A., Ode, A. D., and Oke, I. O. (2019). Microbiological Assessment Of Three Frozen Marine Commercial Fishes. *Journak of Applied Tropical Agriculture*, *24*(1), 241-246.

Adedeji, O. B., Okeretugba, P. O., Innocent-Adide, H. C., and Okonkwo, I. O. (2012). Benefits, Public Health Hazards and Risks Associated with Consumption of Sea Food. *New York Science Journal*, *9*(4), 33-61.

Ahmed, I., Jan, K., Fatma, S., and Dawood, M. A. O. (2022). Muscle proximate composition of various food fish species and their nutritional significance: A review. *Journal of Animal Physiology and Animal Nutrition*, *106*, 690–719.

Ali, I. H. A. A., Salman, A. M., El Ayis, A. A., and Hamad, E. M. (2020). Enumeration of E. coli, Coliform and Aerobic Bacteria in Marine Fish in Port Sudan, Red Sea State, Sudan. *Asian Journal of Research in Animal and Veterinary Sciences*, *6*(3), 9-14.

Alkuraieef, A. N., Alsuhaibani, A. M., Alshawi, A. H., Alfaris, N. A., and Aljabryn, D. H. (2021). Chemical and microbiological quality of imported chilled, frozen, and locally cultured fish in Saudi Arabian markets. *Food Science and Technology*.

Alsuhaibani, A. M., Amal, N. A., Amal, H. A., and Amani, H. A. (2020). Effect of Frozen Storage on Nutritional, Microbial and Sensorial Quality of Fish Balls and Fish Fingers Produced From Indian Mackerel. *Current Research in Nutrition and Food Science*, *8*(3), 852-861.

AOAC. (2012). Official Methods of Analysis of Association of Official Analytical Chemists AOAC International. *Association of Official Analytical Chemists, 19th Edition. Washington, DC*.

AOAC. (2016). Official Methods of Analysis of Association of Official Analytical Chemists AOAC International. *Association of Official Analytical Chemists, 20th Edition, Arlington, Virginia, USA*.

Arendrup, M. C., Karin, M. J., Nicolien, H., and Paul, E. V. (2021). ISO standard 20776-1 or serial 2-fold dilution for antifungal susceptibility plate preparation: that is the question! *Journal of Antimicrobial Chemotherapy*, *76*, 1793–1799.

Aubourg, S. b., Lugasi, A., Losada, V., Hóvári, J., Lebovics, V., and Jakóczi, I. (2012). Effect of pre-soaking whole pelagic fish in a plant extract on sensory and biochemical changes during subsequent frozen storage. 1-22.

Babalola, A. F., Adeyemi, R. S., Adeseye, O. O., Motolani, M. S., Olaitan, O. O., and Gbola, R. A. (2011). Proximate and mineral composition in the flesh of five commercial fish species in Nigeria. *Internet Journal of Food Safety*, *13*, 208-213.

Baoguo, L., Hoa, T. T., Heng, Z., Quanyou, G., and Song, L. (2020). Freezing methods affect the characteristics of large yellow croaker (Pseudosciaena crocea): use of cryogenic freezing for long-term storage. *Food Science and Technology*, *40*(2), 429-435.

Bello, M. M., Oyebola, O. O., and Lawal, T. H. (2019). Proximte composition and microbial analysis of common marine fishes consumed in Maiduguri Metropolis, Borno State, Nigeria. *International Journal of Agric. and Agricultural Tech.*, *11*(1), 113-126.

Binienda, Z. K., Sarkar, S., Silva-Ramirez, S., and Gonzalez, C. (2013). Role of free fatty acids in physiological conditions and mitochondrial dysfunction. *Journal of Food and Nutrition Sciences*, *4*(1), 6-15.

Burke, A. B. (2011). The Proximate, Fatty Acid and Mineral Composition of the Muscles of Cultured Yellowtail (*Seriola lalandi*) at Different Anatomical Locations. 1-35.

Brasky, T. M., Lampe, J. W., Potter, J.D., Patterson, R.E. and White E. (2010). Specialty supplement and breast cancer risk in the vitamin lifestyle (VITAL) cohort. *Cancer Epidemiology preview* 19, 1696-1708.

Cheesbrough, M. (2005). *District laboratory practice in tropical countries, part 2*.Cambridge university press.

Daniel, E. O., Ugwueze, A. U., and Igbegu, H. E. (2013). Microbiological quality and some heavy metals analysis of smoked fish sold in Benin City, Edo State, Nigeria. *World Journal of Fish Marine Science*, *5*(3), 239-243.

Dauda, A. B., Omosalewa, O. O., and Garuba, A. M. (2020). Preference and perception of fish processors on the influence of wood types on the quality of smoked-dried fish in Katsina State. *Proceedings of the 35th Annual National Conferenve of Fisheries Society of Nigeria (FISON)*, 357-361.

Ekanem, J. O., & Udoma, I. G. (2021). Bacteriological assessment of some frozen fishes sold at Ator market in Ikot Ekpene metropolis. *Global journal of pure and applied sciences, 27*, 355-359. copyright© bachudo science co. Ltd printed in Nigeria ISSN 1118-0579.

Ezemba, C., Eze, S. & Archibong, E. (2017). Bacteriological Analysis of Iced Fish Retailed at Eke-Awka Market, Anambra State. *International Journal of Research in Pharmacy and Biosciences*, *4*, (8), 1-9.

Elaigwu, A. M. (2019). The proximate composition, amino acid profile and chemical indices in five freshwater fishes from Tiga Dam Reservoir, Nigeria. *Croatian Journal of Fisheries*, *77*(2), 87-92.

FAO. (2014). Food and Agriculture Organization. Quality of fish and fish products. Fisheries and Agriculture for a World Without Hunger. *Food and Agriculture Organization (FAO), Rome, Itely*.

Fawole, O. O., Oyelese, O. A., and Etim, E. U. (2018). Organoleptic and Chemical Assessment of Two Frozen Marine Fishes Obtained From Markets in Four Agricultural Zones of Oyo State, Nigeria. *Ife Journal of Science*, *20*(2), 337-343.

Gilbert, R. J., Louvois, D. J., Donovan, T., Little, C., Nye, K., Ribeiro, C. D., J Richards, J., Roberts, D., and Bolton, F. J. (2000). Guidelines for the microbiological quality of some ready-to-eat foods sampled at the point of sale. *Communicable Disease and Public Health*, *3*(3), 163-167.

Glover-Amengor, M., Ottah, Atikpo, M.A., Abbey, L.D., Hagan, L., Ayin, J., & Toppe, J. (2012). Proximate Composition and Consumer Acceptability of Three Underutilised Fish Species and Tuna Frames. *World Rural Observ*ation,*4*(2),65-70. http://www.sciencepub.net/rural. 11

Guizani, E. S., and Moujahed, N. (2015). Atlantic mackerel amino acids and mineral contents from the Tunisian middle eastern coast. *International Journal of Agricultural Policy and Research*, *3*(2), 77-83,.

Haizhou, W., Bita, F., Mehdi, A., and Ingrid, U. (2022). Five cuts from herring (Clupea harengus): Comparison of nutritional and chemical composition between co-product fractions and fillets. *Journal of Food Chemistry*, *10*(16), 1-12.

Hellberg, R. S., Dewitt, C. A. M., & Morrissey, M. T. (2012). RiskBenefit Analysis of Seafood Consumption: A Review. Comprehensive *Reviews in Food Science and Food Safety*, 11(5), 490-517.

Huong, D. T. T. (2014). The effect of smoking methods on the quality of smoked Mackerel. *United Nations University Fisheries Training Programme, Iceland [final project]*.

IFOS. (2011). International Fish Oils Standard. *Fish oil purity standards*.

Ismaniza, I., Idaliza, M., and Saleh. (2012). Analysis of heavy metals in water and fish (Tilapia sp.) samples from Tasik Mutiara, Puchong. *Malaysian Journal of Analytical Sciences*, *16*(3), 346-352.

Kimura, I., Atsuhiko Ichimura, Ryuji Ohue-Kitano, and Igarashi, M. (2019). Free Fatty Acid Receptors in Health and Disease [Reviews]. *Journal of american Physiological society*, *10*(2), 1-45.

Koppers, A. J., Garg, M. L., and Aitken, R. J. (2010). Stimulation of mitochondrial reactive oxygen species production by unesterified, unsaturated fatty acids in defective human spermatozoa. *Free radical biology and medicine*, *48*(1), 112-119.

Lall, S. P., and Kaushik, S. J. (2021). Nutrition and Metabolism of Minerals in Fish. *Animals*, *11*(9), 2711.

Malik, I. A., Elgasim, A. E., Oladipupo, Q. A., Asmahan, A. A., and Isam, A. M. A. (2021). Effect of frozen storage on the biochemical composition of five commercial freshwater fish species from River Nile, Sudan. *Food Science and Nutrition*, *9*, 3758–3767.

Mervat, K. I. R. (2008). Evaluation of Nutritional and Hygienic Quality of Herring Fish (*Clupea harengus*) and its Products. *Asssiut Vet. Med. J.*, *54*(119), 1-14.

Mohammad, R., Saad, A., and Yasin, M. (2019). Study of Changes in Fatty Acids Contents (ω3, ω6) and Chemical Quality Indicators in Frozen (Scomber japonicus) from the Marine Waters of Tartus. *Tishreen University Journal for Research and Scientific Studies - Biological Sciences Series*, *14*(6), 93-111.

Murthy, L. N., Kumar, A., Jeyakumari, A., and Nilavan, E. (2019). Training Manual on "Microbiological examination of seafood pathogens with special reference V.mimicus & V.valnificus". *Mumbai Research Center of Central Institute of Fisheries Technology (Indian Council of Agricultural Research*, 69.

NAFDAC. (2015). Nigeria Agency for Drug Administration and Control. *NAFDAC, Nigeria*.

Njinkoue, J. M., Gouado, I., Tchoumbougnang, F., Ngueguim, J. Y., Ndinteh, D. T., Fomogne-Fodjo, C. Y., and Schweigert, F. J. (2016). Proximate composition, mineral content and fatty acid profile of two marine fishes from Cameroonian coast: Pseudotolithus typus (Bleeker, 1863) and Pseudotolithus elongatus (Bowdich, 1825). *Nutrition and Food Science Journal*, *4*, 27-31.

NPC. (2006). National Population Commission. *National Population Commission, Census 2006*.

Nurnadia, A., Azrina, A., Amin, I., Yunus, M. A., and Effendi, M. H. I. (2013). Mineral contents of selected marine fish and shellfish from the west coast of Peninsular Malaysia. *International Food Research Journal*, *20*(1), 431–437.

Nurnadia, A. A., Azrina, A., and Amin, I. (2011). Proximate composition and energetic value of selected marine fish and shellfish from the West coast of Peninsular Malaysia. *International Food Research Journal*, *18*(1), 137-148.

Okpanachi, M. A., Yaro, C. A., and Bello, O. Z. (2018). Assessment of the Effect of Processing Methods on the Proximate Composition of Trachurus trachurus (Mackerel)

Sold in Anyigba Market, Kogi State. *American Journal of Food Science and Technology*, *6*(1), 26-32.

Olagbemide, P. T., and Akharaiyi, F. C. (2021). Evaluation of microorganisms associated with vended frozen fish in Ado Ekiti locality. *Food Research*, *5*(4), 21-28.

Olopade, O. A. (2015). Effect of Poor Handling on The Nutritional Composition of Some Imported Frozen Fishes in Nigeria. *Bulletin UASVM Food Science and Technology*, *72*(1), 20-26.

Olutimehin, I. O., Adejuyigbe, I. J., and Fasuhanmi, O. S. (2019). Effects of Handling and Storage Systems on the Lipid Oxidation and Fatty Acid Level of the African Snakehead Fish (*Parachanna Obscura*). *International Journal of Engineering Research & Technology (IJERT)*, *8*(7), 82-90.

Omolara, O. O., and Omotayo, O. D. (2009). Preliminary Studies on the effect of processing methods on the quality of three commonly consumed marine fishes in Nigeria. *An international journal published by the Nigerian Society for Experimental Biology*, *21*(1), 1-7.

Padmavati, G. (2017). Proximate and elemental composition of Stolephorus commersonnii (Lacepede, 1803) from the coastal waters of South Andaman. *Indian Journal of Geo Marine Sciences,*, *46*(5), 1000–1007.

Palani, K. M., Ruba, A. A., Jeya, S. R., and Shanmugam, S. A. (2014). Proximate and major mineral composition of 23 medium sized marine fin fishes landed in the Thoothukudi Coast of India. *Journal of Nutrition and Food Science*, *4*(1), 1-7.

Raffic, A. S. S., Abdhakir, E. S., and Muthukkaruppan, R. (2020). Proximate and mineral composition of commercially important marine fin fishes from the Kasimedu fish landing centre Chennai. *Journal of Fisheries and Life Sciences*, *5*(1), 20-25.

Rubaijaniza, A., Jessica, L. N., Clovice, K., and John, D. K. (2021). Microbiological Quality of Traditionally Smoked Fish from Lake Victoria Crescent, Uganda. *Food Science and Quality Management*, *104*(1), 47-53.

Silvia, T., Ana, C. D. A., Saldanha, P., Dario, M., Picone, G., Francesca, S., Maria, T. R.-E., Massimiliano, P., Francesco, C., and Pietro, R. (2020). Quality Changes during Frozen Storage of Mechanical-Separated Flesh Obtained from an Underutilized Crustacean [open access]. *Food and Nutrition Bulletin*, *9*(1485).

Speranza, B., Racioppo, A., Bevilacqua, A., Buzzo, V., Marigliano, P., Mocerino, E., Scognamiglio, R., Corbo, M. R., Scognamiglio, G., and Sinigaglia, M. (2021). Innovative Preservation Methods Improving the Quality and Safety of Fish Products: Beneficial Effects and Limits. *Foods*, *10*(11), 2854. https://doi.org/10.3390/foods10112854

Stanton, C., Egerton, S., Mannion, D., Culloty, S., Whooley, J., and R.P, R. (2020). The proximate composition of three marine pelagic fish: Blue whiting (*Micromesistius poutassou*), Boarfish (*Capros aper*) and Atlantic herring (*Clupea harengus*). *Irish Journal of Agricultural and Food Research*, *59*(1), 185-200.

Taiwo, I. O., Olopade, O. A., and Bamidele, N. A. (2017). Microbial load of some imported frozen fish species in Lagos, Nigeria. *Nigerian Journal of Animal Production*, *44*(3), 152-160.

Tenyang, N., Womeni, H. M., Linder, M., Tiencheu, B., Villeneuve, P., and Tchouanguep Mbiapo, F. (2014). The chemical composition, fatty acid, amino acid profiles and mineral content of six fish species commercialized on the Wouri river coast in Cameroon. *La Rivista Italiana Delle Sostanze Grasse Grasse*, *91*(1), 129-138.

Tsegay, T., Natarajan, P. and Zelealem T., (2016). Proximate and mineral composition of some commercially Imported fish species of tekeze reservoir and lake Hashenge, Ethiopia. *International Journal Fisheries and Aquaculture Studies*; 4(1): 160-164

USDA Food Safety Information. (2013). Freezing and Food Safety ,ht p://www. fsis.u sda.gov/wps/wcm/connect/cce745c9-0fc9-4ce6-a50c -84363e5b5a48/Freezing_and_Food_Sa fety .pdf?MOD=AJPERES.

URBAN SILVOPASTURAL AGROFORESTRY: INTEGRATION OF SNAIL PRODUCTION STRATEGY FOR COMBATING FOOD INSECURITY

OGUNSUSI, KAYODE
Department of Forestry, Wildlife and Environmental Management, Olusegun Agagu University of Science and Technology, Okitipupa
Email: k.ogunsusi@oaustech.edu.ng. Telephone +2348060426301

Abstract

Urban silvopasture system that includes productive trees, shrubs, and arable crops with free ranging snails offers an alternative solution to the problem of food insecurity in a deregulated economy. The study was carried out in Ode-Irele, Ondo state, Nigeria. Data on vegetation and snail composition was collected within $10m^2$plots and analyzed using descriptive statistics. Findings of the study show that urban silvopastural agroforestry system is associated with 32 species of trees and shrubs, while arable crops constitute 25 species. The results show that 13 species of giant land snails are associated with the study site. Species abundance was highest for *Achatina achatina* and *Limicolaria aethiops* among the giant land snails and small land snails respectively. Free ranging snails can be incorporated into urban silvopastural agroforestry system, as an alternative solution with potential to overcome the critical barrier of food insecurity.
Keywords: Agroforestry, food, insecurity, silvopasture, snails, urban,

Introduction

The demand for food and other agricultural products is projected to increase by 50 percent between 2012 and 2050. Demand will undergo structural changes, owing to factors such as population growth, urbanization, and per capita increases in income, while the natural resource base upon which agriculture depends will become increasingly stressed (FAO, 2017). In the face of global food production challenges, devising means of enhancing food security cannot be under-estimated. To surmount the challenge of food insecurity, agroforestry especially in the urban setting has the capacity to blend forestry and agricultural practices. Also, agroforestry can enhance the diversification of income streams (Bentrup *et al.*, 2021). Urban agroforestry refers to the incorporation of trees and other perennial crops into urban, sub-urban, and other community spaces. Typically, three basic sets of components which include woody perennials, herbaceous plants (agricultural/arable crops) and animals are managed in all agroforestry systems. Evidence suggests that agroforestry can sustainably increase production per unit of land area while maintaining or enhancing other economic, social, and environmental services (Muschler, 2016). Based on available scientific evidence, agroforestry can facilitate the migration of wildlife such as snails to more favorable conditions (Bentrup *et al.*, 2021).

Silvopasture is a form of agroforestry that can rely on fewer external inputs, maximize use of space, or diversify farm's revenue streams with livestock such as snails which are mini-livestock. Silvopasture is a form of agroforestry that integrates trees, livestock, and pasture in a mutually beneficial way, optimizing land use while maintaining environmental sustainability. This practice not only promotes biodiversity but also enhances the productivity and resilience of agricultural systems. Silvopasture systems have been studied for their potential benefits, such as improved soil health (Rachman *et al.*, 2020), enhanced water retention, increased carbon sequestration (Idol *et al.*, 2011), and diversification of income for

farmers. Silvopasture also enhances biodiversity. By combining trees with pasture and livestock, these systems create a more varied habitat that can support a greater number of species. According to Pent *et al*. (2019), this practice provides niches for both native flora and fauna, increasing species richness and ecosystem complexity. Additionally, silvopasture systems can serve as corridors for wildlife movement, thereby reducing habitat fragmentation. From an economic perspective, silvopasture offers several opportunities for farmers to diversify income streams. Livestock can continue to graze while benefiting from the shade provided by trees, which can improve animal welfare and productivity. Moreover, tree products such as timber, fruits, and nuts can be harvested and sold, generating additional revenue. According to Carter and Jackson (2012), integrating tree crops can offer lucrative returns while maintaining pastoral systems. In regions where forest cover is high, silvopasture provides a way to make land use more efficient, especially when conventional agriculture might be unsustainable. For instance, Silva and Rosati (2014) found that silvopasture in Mediterranean regions allowed farmers to optimize land use and mitigate the effects of drought by providing a diversified system that could buffer against climatic variability.

Animal welfare is often improved in silvopasture systems due to the shade and shelter that trees provide, reducing heat stress, altering the microclimate, and improving comfort for grazing animals (Castillo *et al.,* 2020). According to Poudel *et al.,* 2022, lower heat stress and improved welfare within the silvopasture system can also help improve livestock gain and reproductive performance. compared to animals in open, sun-exposed pastures. The presence of trees can also provide protection from predators, enhancing the safety of livestock. In addition to improving physical comfort, silvopasture systems often encourage natural behaviors in livestock. Grazing animals tend to browse and graze more freely in environments with trees, which can enhance their health and reduce the need for supplementary feed.

Problem Statement and Justification

With the many benefits of urban silvopastoral agroforestry, landscape designers and urban planners are encouraged to use multifunctional landscape approach to integrate food production into the structure of the city (Lovell, 2010). Despite the growing awareness about the practice of silvopastoral agroforestry, this type of agriculture is yet to be fully integrated into the urban environment (Muschler, 2016). To overcome the challenge of food insecurity, silvopastoral agroforestry in the urban setting has the capacity to blend forestry and agricultural practices. Silvopastoral agroforestry-induced diversification of income streams can help safeguard agricultural production under the many uncertainties from shifting markets (Bentrup *et al.,* 2021).

Materials and Method

The study was carried out in Ode-Irele, Ondo state, Nigeria. Data on urban agroforestry tree and shrub cover, and snail composition was collected within 15 plots measuring $10m^2$. Data on snails within urban silvopastural agroforestry canopy was collected two times at the onset of the raining season. Collected data was analysed using descriptive statistics.

Results and Discussion

Species Abundance and Diversity of Arable/Agricultural Crops

The results on diversity and relative abundance of tree with shrubby plants and arable crops show that the urban agroforestry system is associated with 32 species of trees and shrubs, while arable crops constitute 25 species (Table 1). These results show that with the diversified tree, shrub and arable crops strata, urban silvopastural agroforestry could become sources of income for the varieties of products that they can produce. The diversity of trees, shrubs and arable crops in the urban agroforestry can be integrated into any number of urban landscapes,

including urban farms (Muschler, 2016), which can also provide a more favourable condition for the rearing of snails (Bentrup *et al.*, 2021).

Table 1: Relative Abundance of Trees with Shrubs and Arable Crops

S/N	Common Name	Scientific Name	Total (n = 15)	Number of plots	Mean	Common Name	Scientific Name	Total (n = 15)	Number of plots	Mean
	Perennial Trees					**Arable Crops**				
1	Cashew	*Anarcadium occidentale*	3	3	1	Water yam	*Dioscorea alata*	14	2	7
2	African Native Pear	*Dacryodes edulis*	4	4	1	White yam	*Dioscorea rotundata*	40	5	8
3	Pawpaw	*Carica papaya*	19	9	2	Cocoyam	*Xanthosoma sagittifolium*	59	7	66
4	Oil palm	*Elaeisguineensis*	4	4	1	Pineapple	*Ananas comosus*	103	9	11
5	Guava	*Psidium guajava*	3	3	1	Nigerian spinach	*Celosia argentea*	25	3	8
6	Sour soup	*Annona muricata*	4	3	1	Pumpkin	*Cucurbita pepo*	5	2	3
7	Moringa	*Moringa oleifera*	3	2	2	Fireweed	*Crasscocephalumcrepidioides*	14	1	14
8	Leucaena	*Leucaena leucocephala*	7	4	2	Sugar cane	*Saccharium officinarum*	2	1	2
9	Plantain	*Musa parasidiaca*	52	5	10	Garden egg	*Cucumis sativus*	7	2	4
10	Sweet orange	*Citrus sinensis*	4	4	1	African arrowroot	*Canna indica*	18	2	9
11	Lime	*Citrus aurantifolia*	3	3	1	Trifoliate yam	*Dioscorea dumentorum*	11	2	6
12	Pepper fruit	*Uvariodendron mirabile*	5	5	1	Bryophyllum	*Bryopyllumpinnatum*	13	3	7
13	Mango	*Mangifera indica*	5	5	1	Fluted pumpkin	*Telfaria occidentalis*	12	3	4
14	White butterfly	*Clerodendron volubile*	24	7	3	Soft cane	*Thaumatococcosdanieli*	30	2	15
15	Cocoa	*Theobroma cacao*	6	5	1	Jute mallow	*Cochorusolitorius*	19	1	19
16	Coconut	*Cocos nucifera*	6	5	1	Waterleaf	*Talinum triangulare*	154	7	22
17	Tangerine	*Citrus reticulate*	2	2	1	Gale-of wind	*Phylantusamarus*	30	2	15
18	Kola	*Cola acuminate*	3	3	1	Tree spinach	*Cnidoscolus aconitifoli*	4	1	4
19	Combretum	*Combretum spp*	3	1	3	Green Amaranth	*Amaranthus hybridus*	144	2	72
20	African star apple	*Chrysophylum albidum*	1	1	1	African egg plant	*Solanum macrocarpo*	45	3	15

							n			
21	Avocado pear	*Persea Americana*	3	3	1	Tomato	*Lycopersicum esculentum*	52	3	17
22	Bitter leaf	*Vernonia amygdalina*	2	2	1	Okra	*Abelmoschus esculentus*	9	1	9
23	Chewing stick	*Masularia acuminate*	2	2	1	Pepper	*Capsicum annuum*	38	2	19
24	European/ common pear	*Pyrus physalis*	1	1	1	African spinach	*Basella alba*	3	1	3
25	Phalsa	*Grewia spp.*	2	2	1	Yellow yam	*Dioscorea cayenesis*	11	1	11
26	Banana	*Musa sapientus*	13	2	7					
27	Bokonisa	*Beilschmiedi amannii*	1	1	1					
28	Kola	*Cola nitida*	1	1	1					
29	Scent leaf	*Ocimumgratissimum*	16	3	5					
30	Grape	*Citrus paradise*	1	1	1					
31	Breadfruit		1	1	1					
32	Scent leaf (Small leaves)	*Ocimumbasilicum*	34	2	17					

Species Abundance and Diversity of Snails in Urban Agroforestry

Species abundance and diversity of snails in urban silvopastural agroforestry system is presented in Table 2. The results show that 13 different species of land snails are associated with the urban silvopastural agroforestry. Species abundance was highest for *Achatina achatina*, followed respectively by *Achatina fulica, Lissachatina fulica, Archachatina marginata ovum, Archachatina marginata suturalis* among the giant land snails. Among the small land snails, species abundance was highest for *Limicolaria aethiops*, followed respectively by *Limicolaria aethiops albino, Limicolarianumidica.* The number of different species of snails associated with the urban silvopastural agroforestry is a pointer to the fact that forestry and agricultural practices can be blended for income diversification. These results support the fact that under many uncertainties from shifting markets especially in a deregulated economy, agroforestry-induced diversification of income streams can help safeguard agricultural production (Bentrup *et al.*, 2021) to solve the problem of food insecurity.

Table 2. Species Abundance and Diversity of Snails

S/No	Snail Species	Abundance		Total	Mean
		Plot 1	Plot 2		
	Giant Land Snails				
1	*Archachatina marginata ovum*	12	23	35	18
2	*Archachatina marginata albino*	11	6	17	9
3	*Archachatina marginata xxl*	6	4	120	5
4	*Archachatina marginata suturalis*	8	19	17	9
5	*Achatina achatina*	183	205	388	194
6	*Achatina fulica*	115	195	310	155

7	*Lissachatinafulica*	72	51	123	98
	Small Land Snails				
8	*Limicolaria aethiops*	45	61	106	53
9	*Limicolaria aethiops albino*	21	27	48	24
10	*Limicolaria flammea*	11	18	29	15
11	*Limicolaria aurora*	7	3	10	5
12	*Limicolaria numidica*	13	21	34	17
13	*Limicolaria agathina*	13	5	18	9

Conclusion and Application

From the findings of this study, it can be concluded that free ranging snails can be incorporated into urban silvopastoral agroforestry. Urban silvopastoral agroforestry systems that include productive trees, shrubs, and arable crops with free ranging snails may, therefore offer an alternative solution with potential to overcome the critical barrier of food insecurity.

References

Bentrup, G., Schoeneberger, M., Patel-Weynand, T., Jose, S. and Karel, T. H. (2021). Agroforestry: Enhancing Resiliency in U.S. Agricultural Landscapes under Changing Conditions. Pp 1 -6.

Carter, R. C., and Jackson, S. R. (2012). "Agroforestry practices for increased productivity." *Agroforestry Systems*, 84(1), 55–65.

Castillo, M. S., Tiezzi, F. and Franzluebbers, A. J. (2020). Tree species effects on understory forage productivity and microclimate in a silvopasture of the Southeastern USA. Agriculture, Ecosystems & Environment, 295: 106917. https://doi.org/10.1016/j.agee.2020.106917.

FAO (2017). The future of food and agriculture: Trends and challenges. Rome. ISBN 978-92-5-109551-5. Pp 180.

Idol, T., Haggar, J. and Cox, L. (2011). Ecosystem Services from Smallholder Forestry and Agroforestry in the Tropics. In: Campbell, W., Lopez Ortiz, S. (eds) Integrating Agriculture, Conservation and Ecotourism: Examples from the Field. Issues in Agroecology – Present Status and Future Prospectus, vol 1. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-1309-3_5

Lovell, S. T. (2010). Multifunctional urban agriculture for sustainable land use planning. *Sustainability*, 2: 2499–2522. Doi: 10.3390/su2082499

Muschler, R. G. (2016). Agroforestry: Essential for Sustainable and Climate-Smart Land Use? Chapter in Pancel, L. and Kohl, M. (eds). Tropical Forest Handbook. 2nd Edition. Springer-Verlag. Pp 2013-2116.

Pent, G. J., Greiner, S. P., Munsell, J. F., Tracy, B. F. and Fike, J. H. (2019). Lamb performance in hardwood silvopastures, I: animal gains and forage measures in summer. Transl Anim Sci, . 2019 Sep 20;4(1): 385–399.

Poudel, S., Fike, J. H. and Pent. G. J. (2022). "Hair Cortisol as a Measure of Chronic Stress in Ewes Grazing Either Hardwood Silvopastures or Open Pastures." *Agronomy* 12(7): 1566.

Rachman, L. M., Hidayat1, Y., Tarigan1, S. D., Sitorus, S. P., Fitri, R. and Ain, A. Q. (2020). The Effect of Agroforestry System on Reducing Soil Erosion in Upstream Ciliwung

Watershed. The 6th International Conference of Jabodetabek. IOP Conf. Series: Earth and Environmental Science, 556: 012010. doi:10.1088/1755-1315/556/1/012010

Silva, L. S., and Rosati, A. (2014). "Silvopasture systems in Mediterranean climates." *Agroforestry Systems*, 88(2), 265–274.

Smith, J., Pearce, B. D. and Wolfe, M. S. (2013). Reconciling productivity with protection of the environment: Is temperate agroforestry the answer? *Renewable Agriculture and Food Systems*. 28(1): 80–92.

ADMINISTRATION OF *BRIDELIA FERUGENEA* (BENTH) LEAVES EXTRACT REGULATES PRO-INFLAMMATORY CYTOKINES AND DPP4 MRNA IN HEPATIC TISSUE OF DIABETIC MODEL RATS

***Cecilia Oluwamodupe**
[1] Department of Chemical Sciences (Biochemistry Program), Olusegun Agagu University of Science and Technology Okitipupa Ondo State, Nigeria
E-mail address: ce.oluwamodupe@oaustech.edu.ng

Abstract

Diabetes mellitus is a metabolic disorder that is threatening the global health, it affects all systems in the body, including the liver. *Bridelia ferruginea* (Benth) leaves, bark and stem are traditionally used in Nigeria for the treatment of inflammation and diabetes mellitus. Although, the molecular mechanisms behind this effect are yet to be exclusively explored. This research hypothesized that antidiabetic action of *Bridelia ferruginea* leaves maybe by regulating the expression of proinflammatory cytokines which are interleukin-6(IL-6), interleukin-10 (IL-10), interleukin-1beta (IL-1 β), tumor necrosis factor alpha (TNFά) and inhibition of Dipeptidyl peptidase-4(DPP4) messenger RNA (mRNA) in liver. Diabetic was model using streptozotocin and animals were grouped and treated with extract of *Bridelia ferruginea* leaves and Metformin. Blood glucose and body weight were monitored after 21 days, animals were fasted overnight and sacrificed. Liver was perfused and harvested. Total RNA was extracted from the liver tissues using TRIzol reagent. The resulting PCR amplicons were subjected to 1% agarose gel electrophoresis. Snapshots revealing the relative density of DNA bands were taken. Diabetic caused a significant increase in the expression of all the proinflammatory and DPP4 genes in the liver compared to control but oral administration of BF significantly suppress the expression compared to diabetic control especially at 100mg/kg body weight. The observed results showed a good and promising drug candidate with anti-inflammatory, antioxidant and antidiabetic action.
Keywords: medicinal plant, diabetes, cytokines, proinflammation, DPP4, *Bridelia ferruginea*

Introduction

Diabetes mellitus (DM) is a group of chronic metabolic disorder indicated by an elevated level of blood sugar over an extended period. Symptoms of high blood sugar include urgent urination, polydipsia, and polyphagia. (WHO, 1999) Serious long-term complication includes cardiovascular disease, stroke, chronic liver disease, foot ulcers, and damage to the eye. (WHO, 1999)

The liver plays an important part in regulating glucose metabolism since it reserves glycogen in the fed state and produces glucose through the biochemical breakdown of this glycogen under the regulation of phosphorylase kinase and glycogen phosphorylase and produce glucose from lipid and protein in the post absorptive phase. In physiological conditions, hepatocytes are the main site of hepatic glucose metabolism; however, a small, but significant, role in insulin metabolism is played by non-parenchymal liver cells that contribute to insulin degradation and are involved in the modulation of hepatocyte glucose metabolism during inflammatory processes via the release of cytokines (Manna et al. 2010). This is followed by derangement of protein, carbohydrate and lipid metabolism, thus leading to increased oxidative stress and further eliciting the inflammatory cascade, which further

contribute to agglomeration of excessive fat cells in the liver which will lead to fatty liver and, resulting to, Non-Alcoholic fatty liver disease in certain cases (Elekofehinti et al.2021)

Previous studies have shown that proinflammatory cytokines (Il-1, Il-2, and TNF- α) play a pivotal role in the pathogenesis of autoimmunity and β-cell damage and the therapeutic relevance of GLP-1 is currently well established since enhancement of the half-life of GLP-1 upon treatment with dipeptidyl peptidase 4 inhibitors (DPP4i) or activation of the GLP-1 receptor by exendin-4 derivatives have been proven efficacious in the treatment of type 2 diabetes (Ejelonu et al. 2021). Therefore, the direct stimulation of intestinal GLP-1 release by DPP4 inhibition could constitute another promising GLP-1-based therapeutic approach for the treatment of metabolic diseases. (Ejelonu et al. 2021). Medicinal plants have long been used for therapeutic purposes, and plant metabolites and their derivatives have provided us with a high proportion of today's successful pharmaceuticals (Akinmoladun et al. 2010)

Despite the prominent use of *Bridelia ferruginea* (Euphorbiaceae) as a local herb, serious scientific proof on its medicinal capabilities is still rare and sporadic (Odetola et al. 2006; Hamid et al. 2013). Consequently, more research, scientific explanation and persistent verification are needed to flag its significance in the treatment of diabetes and other associate metabolic conditions.

Methods

Plant collection and preparation of extract

Fresh leaves of *Bridelia ferruginea* were collected from the horticulture garden of the Federal University of Technology Akure. The leaves were washed thoroughly with distilled water and air dried at room temperature (28 ± 3 ◦C). The dried leaves were pulverized into fine powder using an analytically clean blender and extracted according to Ejelonu *et al.*, 2017 method.

Table 1: Reverse transcription-polymerase chain reaction primer sequences.

Genes		Sequence (5′-3′)
IL-6	Forward	TCCTACCCCAACTTCCAATGCTC
	Reverse	TTGGATGGTCTTGGTCCTTAGCC
IL-1β	Forward	CACCTCTCAAGCAGAGCACAG
IL-10	Reverse	GAGAGAAGCTGAAGACCCTCTG
	Forward	TCATTCATGGCCTTGTAGACAC
	Reverse	GCAAGACGTGGGTAATGATG
DPP-4	Forward	AGCCTGGTTGGGTTTGTATG
	Reverse	GGGTTCCATGGTGAAGTCAAC
TNF-α	Forward	AAATGGGCTCCCTCTCATCAGTTC
	Reverse	TCTGCTTGGTGGTTTGCTACGAC
β-actin	Forward	TCA CCC ACA CTG TGC CCC ATC TAC GA
	Reverse	CAG CGG AAC CGC TCA TTG CCA ATG G

Animals

A total of 48 wistar rats of average weight 178 ± 29g were procured and kept in galvanized cages at room temperature in the animal house of biochemistry program Olusegun Agagu university of Science and Technology Okitipupa, Nigeria. The rats had free access to normal rat chow and water ad libitum on a 12 h light/12 h dark cycle. They were handled and used in accordance with the National Institute of Health (NIH) Guidelines for the Care and Use of

Laboratory Animals.

The rats were grouped and administered with B. *ferruginea* using an oral gavage needle for twenty one (21) days and during the treatment period, the FBG levels of all rats were measured seven days interval. Blood samples were collected from each rat's tail vein, and FBG were measured using Accu check glucometer. The animals were sacrificed by anaesthetization and Liver removed into trizol solution and stored at -20 ◦C till analysis period.

RNA isolation and reverse transcriptase polymerase chain reaction (RT-PCR)

Total RNA was extracted from the liver tissues using TRIzol reagent (Thermofisher Scientific) according to the manufacturer's instruction.

Statistical analysis

The results are expressed as mean ± SD. Statistical evaluation was carried out using ANOVA followed by Dunnett's test between the groups. Differences were considered significant at $p < 0.05$ and highly significant at $p < 0.01$.

Results

Table 2 Effect of oral administration of methanolic extract of *B. ferruginea* on the body weight of the experimental rats per group.

Test groups	Before treatment	7th day After treatment	14th day	21st day
Control	176±0.36	177±0.31	179±0.42	181±0.34
Metformin treated	207±5.90	187±5.30	189±30.42	190±0.39
Diabetic control	192±1.83	170±2.42	166±1.75	142±12.62
Bf 100mg/kg bw	186±5.9	162±2.12	165±2.87	173±60.151
Bf 200mg/kg bw	190±1.08	159±7.66	163±27.34	183±13.40
Bf 500mg/kg bw	177±0.92	151±2.40	155±10.31	169±2.87

*Bf= *Bridelia ferruginea,* bw= body weight, n= 8 = means ± SD

Table 3 Effect of oral administration of methanolic extract of *Bridelia ferruginea* leaves on the fasting blood glucose (mg/dl) of the experimental rats per group.

Test groups	Before treatment	1st day After treatment	7th day	14th day	21st day
Control	98.17±5.95	106±7.24	116±11.15	96±10.30	99±5.95
Metformin treated	90.66±1.16	395±21.20	312±10.10	233±60.10	193±14.75
Diabetic control	92.50±2.20	363±20.43	366±3.46	357±16.30	350±30.29
Bf 100mg/kg bw	95.33±3.71	360±33.91	282±74.12	217±60.22	119±26.55
Bf 200mg/kg bw	101.50±4.52	395±33.51	296±16.10	225±11.20	201±22.51
Bf 500mg/kg bw	97.16±3.63	402±18.79	326±11.10	272±80.10	211±26.90

*Bf= *Bridelia ferruginea;* bw = body weight; FBG in mg/dl, n= 8 = means ± SD

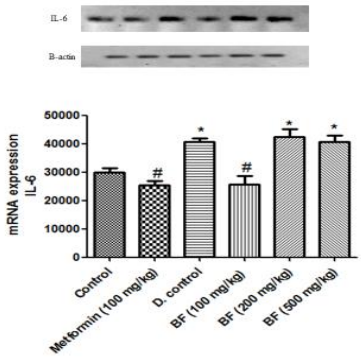


Fig. 1 ***mRNA expression of IL-6 from the hepatic tissues of control and STZ model diabetic rats treated with*** **Bf** ***and metformin. ****

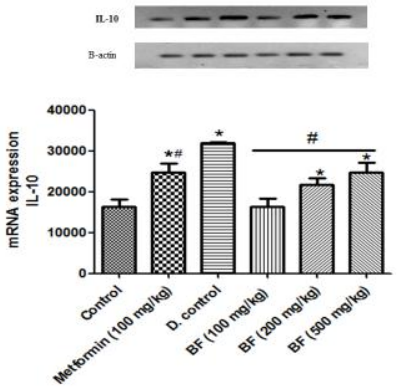


Fig. 2 ***mRNA expression of IL-10 from the hepatic tissues of control and STZ model diabetic rats treated with*** **Bf** ***and metformin***

. * Indicate statistical difference (P<0.05) to control while # indicate statistical difference (P<0.05) to diabetic control

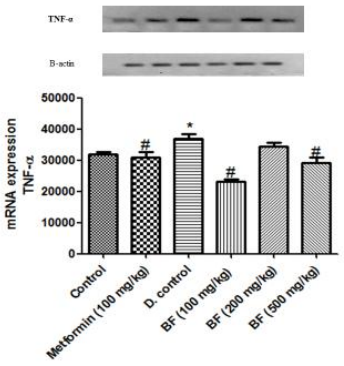


Fig. 3 ***mRNA expression of TNF-ά from the hepatic tissues of control and STZ model diabetic rats treated with*** **Bf** ***and metformin***

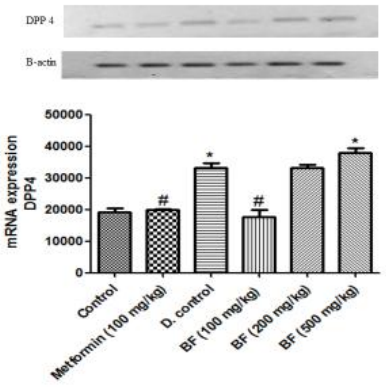


Fig. 4 ***mRNA expression of DPP4 from the hepatic tissues of control and STZ model diabetic rats treated with Bf and metformin.***

* Indicate statistical difference (P<0.05) to control while # indicate statistical difference (P<0.05) to diabetic control. Values are expressed as means ± SD.

Discussion

This study discovered the postulate that methanolic extract of *Bridelia ferugenea* leaves suppressed messenger RNA (mRNA) expression of proinflammatory cytokines, prevent fatty liver, and inhibit DPP4 mRNA expression in the rats with type 2 diabetes induced by streptozotocin. Although previously, several studies that have been carried out already shows the antidiabetic effect of *Bridelia ferugenea* leaves in animal models but none of the research studies investigate clearly these mechanisms of *Bridelia ferugenea* leaves in respect to diabetes.

Effect of oral administration of methanolic extract of *Bridelia ferruginea* on the fasting blood glucose of STZ diabetic model albino rats Table 3 showed that diabetic control rat exhibited significantly ($P < 0.05$) increase in the level of blood glucose on day 7, 14 and 21 compared to normal control rats. The STZ diabetic model rat treated with 100, 200 and 500 mg/bw of *Bridelia ferruginea* showed significant ($P < 0.05$) weekly dependent decrease in the level of

blood glucose on day 7, 14 and 21 compared to diabetic control. This result shows that *Bridelia ferruginea* leave has anti-hyperglycemic effect as earlier reported by Oyebode and her research team (Oyebode et al. 2020).

The role of dipeptidyl peptidase-IV (DPP4) as both a regulatory enzyme and a signaling factor has been examined and illustrated in many studies. DPP4 inhibition results in increased blood concentration of the incretin hormones glucagon-like peptide-1 (GLP-1) and gastric inhibitory polypeptide (GIP). (WHO, 1999).

This causes an increase in glucose-dependent stimulation of insulin secretion, resulting in a reduction of blood glucose levels (Camilleri et al.2015). In figure 6 there is a substantial difference in DPP4 mRNA expression of BF 100mg/kg body weight compared to diabetic control. The dosage 100mg/kg inhibit the expression of DPP4 mRNA compared to diabetic control and there is no significant difference between this dosage (100mg) and metformin (100mg). This agrees with our previous study and other studies that DPP4 inhibitors activate TGR5 and causes GLP1 secretion thereby leading to insulin release (Ejelonu et al. 2021). Studies has also shown that DPP4 inhibitors represent a very low threat of hypoglycemia development.

An adipocyte derived cytokine which is tumor Necrosis Factor -ά (TNF-ά) plays a key role in type 2 diabetes. TNF- ά blights insulin signaling by impeding the function of Insulin receptor substrate 1 (IRS-1) through serine phosphorylation (Ghanim et al. 2001). Fig. 5 shows mRNA expression of TNF -alpha, BF dosage 100mg/kg bw and 500mg/kg bw significantly suppresses the expression of TNF alpha compared to diabetic control in the hepatocyte of streptozotocin model diabetic rats. Excess production of TNF-ά in the hepatic has been suggested to carry a pivotal part in the morbidity of fatty liver disease (Ghanim et al. 2001). This implies that BF at 100mg/kg body weight concentration and concentration of 500mg/kg body weight compete favorably with metformin 100mg/kg body weight to prevent fatty liver diseases and type 2 diabetes by inhibition of TNF production in the liver. The response of hepatic IL-6 and TNF-alpha mRNA to the treatment of BF in this experiment is an indication that BF is a promising remedy to Treatment of type2diabetes and its associated fatty liver diseases. The proposal by Budavari et al 1996 that the insulin resistance syndrome could be an inflammatory disorder appears particularly relevant.as shown in the mRNA expression of all the proinflammatory genes (IL-1β) , (IL-10) , TNF-ά, (IL-6) response to induction of diabetes by STZ. The treatment with 100mg /kg body weight in all the expression remains constantly significantly different compared to diabetic control.

In conclusion, there have been folkloric use of Bridelia ferruginea leaves from time immemorial in treating fever, inflammation and diabetes although concern exist about dosage and mechanism of action. The antidiabetic aftermath of BF was authenticated by the repression of proinflammatory cytokine mRNA expression and by suppressing the expression of DPP4 in STZ diabetic model rats

Conclusion

These findings indicate that *BF* methanolic extract have anti-hyperglycemic and anti-inflammatory effect and is worth applying to human clinical trials although other indices should be measured.

References

Ejelonu OC, Elekofehinti OO, Adanlawo IG (2017). *Tithonia diversifolia* saponin-blood lipid interaction and its influence on immune system of normal wistar rats. Biomedicine & Pharmacotherapy 87: 589-595

Elekofehinti OO, Oyedokun VO, Iwaloye O, Lawal AO, Ejelonu OC (2021).Mormordica Charantia silver nanoparticles modulate SOCS/JAK/STAT and P13K/Akt/PTEN signaling pathways in the kidney of streptozotocin-induced diabetic rats. Journal of Diabetes and Metabolic Disorder. https://doi.org/10.1007/s40200-021-00739-w

Ghanim H, Garg R, Aljada A, Mohanty P, Kumbkarni Y, Assian E (2001) Suppression of nuclear factor-kappaB and stimulation of inhibitor kappaB by troglitazone: evidence for an anti-inflammatory effect and a potential antiatherosclerotic effect in the obese. J Clin Endocrinol Metab 86:1306-12.

Levinthal GN, Tavill AS (1999) Liver disease and diabetes mellitus. Clin Diabetes 17:73-9

Manna P, Das J, Ghosh J, Sil PC(2010) Contribution of type 1 diabetes to rat liver dysfunction

Oyebode O, Ochuko LE , Lindiwe Z , Collins U, Ibeji N, Anthony K, Shahidul I (2020) Invitro and computational studies of the antioxidant and anti-diabetic properties of Brideliaferruginea , Journal of Biomolecular Structure and Dynamics, DOI: 10.1080/07391102.2020.1852961

WHO Consultation. Definition, diagnosis and classification of diabetes mellitus and its complications. Geneva: World Health Organization; 51999. Report No. WHO/NCD/NCS/99.2

EFFECT OF BREED ON GROWTH PATTERN OF BROILER CHICKEN

Olubisi O. Oyeleye*, Adelani A. Adeoye and Fayokemi O. Akosile
Department of Animal Production and Health, Olusegun Agagu University of Science and Technology, Okitipupa, Ondo State, Nigeria.
*Corresponding author email/Phone number: olubisi.oluseun@gmail.com/08160911765

Abstract

This study was carried out to evaluate the breed difference in growth parameters of four different broiler breeds. The experimental units were derived from four commercial broiler breeds namely Aboracre, Cobb, Marshall and Ross. Each breed has (50) chicks in total of 200 birds across the four breeds. The broiler birds were reared for a period of (10 weeks) and all statistical analyses were conducted using various parameters for measurement such as initial body mass, final body mass, specific growth rate and mean weekly increase in weight. At the end of the experiment, there were no significant differences in mean initial body mass, final body mass, specific growth rate and mean weekly weight gain ($p>0.05$). It can be deduced from this study that performance in terms of growth patterns for most of the commercially available breeds studied are similar.
Keywords: Breed, age, growth pattern, broiler chicken.

Introduction

Broiler chickens, also known as meat chickens, are a specific breed of poultry raised primarily for meat production. These chickens are typically bred to have larger and fast-growing bodies (Karnuah, and Sebastian, 2010), which enables them to reach market weight in a relatively short period of time. Broilers are specific type of poultry that are raised and bred for their meat. They are key component of the global poultry industry, which plays a significant role in meeting the ever-growing demand for meat worldwide. Broiler chicken are highly valued for their fast growth rate and efficient conversion of feed into meat, making them a popular choice for commercial meat production. Modern broiler as a result of genetic selection, with the selection pressure being focused on high growth rate, extensive muscle development and relatively low feed consumption (Goliomytis *et al.,* 2003). These factors combine with improved environmental factors such as nutrition and housing have reduced the slaughter age of contemporary broiler chicken to 42 days and slaughter weight in excess of 2kg (Mottet and Tempio, 2017). Artificial selection for fast growth of broiler chickens has resulted in significant changes to the body conformation of the animal. Comparisons of broiler chickens from 1957 to 1991 showed a 450% increase in body weight at 42 days of age (Havenstein *et al.* 2003). It is demonstrated that 85–90% of this increase can be attributed to selective breeding, and 10–15% as a result of nutritional developments (Akbas *et al.* 2009; Havenstein et al. 2003). Selection for conventional, fast-growing broiler chickens has focused on increased pectoral muscle mass (i.e. breast meat) and a heavier body weight that is achieved more quickly. Rapid weight gain results in juvenile broiler chickens carrying a heavy weight on immature bone structure compared to their ancestors, for example, junglefowl at the same age. Paxton et al. (2010) discuss how juvenile junglefowl depend more on larger medial rotators muscle group (rotating part of the hip muscle) for stability, which transitions to a dependence on using abductor muscles (hip muscles which pull the leg sideways away from the body) more for stability into maturity. Broiler chickens develop these muscles at different rates, with abductor muscles growing faster than expected, comparable to adult junglefowl. Physiological measures show that broilers also have less pelvic limb muscle which affects the

amount of support at the hip joint (Paxton *et al.* 2010). Larger abductors and medial rotators were found in the hips of the broiler chickens, whereas junglefowl had longer contracting muscles. The results of these changes in combination with fast growth for heavier body weight at a younger age have reduced the walking ability of broiler chickens compared to junglefowl (Paxton *et al.* 2010, Aggrey *et al.*, 2010). Breeds and age significantly impact broiler chickens in terms of growth rate, feed conversion efficiency, carcass quality, and susceptibility to diseases. Different breeds have been selectively bred for specific traits such as meat yield, growth rate, and disease resistance. For instance, fast-growing breeds like Ross 308 or Cobb 500 are commonly used in commercial broiler production due to their rapid growth and high meat yield. Broiler chickens undergo rapid growth during the first few weeks of life, with the majority reaching market weight within 6 to 8 weeks. As they age, their growth rate slows down, and they become more susceptible to health issues such as skeletal disorders and metabolic diseases. Therefore, proper management practices, including nutrition and housing, are crucial to optimize the performance and welfare of broiler chickens at different stages of growth. Studying breed and age effect of growth pattern provide valuable insight into genetic potential of broiler breeds. By examining growth pattern at different age and breeds, this contribute to the development of broiler lines with improved growth performance, which is crucial for meeting the increasing global demand for poultry meat. The objective of this study was to determine the effects of breed on growth pattern of broiler chicken.

Materials and Methods

Site of the Experiment

The study was conducted at the Teaching and Research Farm of Olusegun Agagu University of Science and Technology, Okitipupa, Ondo State. The climate is relatively dry, occuring between the months of February and May. Okitipupa lies between latitude 6°25 and 6°46 N and Longitude 4°35 and 4°50 E within the tropical rainforest zone of Nigeria. It covers a total land area of 636 sq. Km and has an estimated population of 233.565 people.

Experimental design

A total number of two hundred (200) one-day old of four (4) breeds of broilers were used for the experiment. The breeds include Aboracre, Cobb, Marshall and Ross and each breed consist of (50) birds. The study lasted for ten weeks. The dimension of each pen was 2.01 × 1.00 m and was constructed on a way as to permit proper ventilation. The birds were fed commercial broiler feed ration (2900 Kcal/KgME and 20.00% Crude protein). Fresh feed and clean water were supplied. The feeders and drinkers were served proportionately depending on numbers of birds per group. Vaccination schedule and other management practices were strictly adhered to.

Data collection

At 2nd, 4th, 6th, 8th and 10th week, the birds were deprived of feed to as to be able to collect data from them.The material used are measuring tape, divider, ruler and electronic scale. Measurements of body weight was carried out for 10weeks. The body weight was measured in gram using electronics sensitive scale. Various parameters were used after the measurements which involve:

1. The initial body mass (IBM): which is the weight of chicks at the beginning of the rearing period, typically on the day of hatch or shortly thereafter.

2. Final body mass (FBM): which is the weight of birds at the end of the rearing period, just before they are processed for market.
3. Rearing period: is the duration during which broiler chickens are raised from day-old chicks to market-ready birds. This period typically spans between 6 to 10 weeks, depending on the specific management practices, genetic strains, and market requirements.
The calculations based on data collected are:
:. Body mass gain (BMG): final body mass - initial body mass / initial body mass ×100
:. Specific growth rate (SGR): (log final body mass - initial body mass) / number of trial days ×100
:. Mean weekly increase in weight of the 4 breeds of broilers

Statistical Analysis

The data collected on growth traits were subjected to two way analysis of variance (ANOVA) using (SAS, 2004) and significant means were separated using Duncan Multiple Range Test.(Duncan, 1955), using the model below:

$Yijk = \mu + Bi + Aij + Ɛij$

Where Y is individual observation; μ is universal mean; Bi is effect of breed; Aij is effect of age; Ɛij is error.

Results and Discussion

Results

Table 1 shows the proximate composition of the commercial starter and finisher broiler feeds used. The highest value which is 54.12% carbohydrates and least value which is 4.91% ash for starter feed. Also, highest value which is 48.50% carbohydrates and least value 4.09% fibre for finisher feed.

Table 2 shows the effect of breed of broilers on body mass gain at 4, 6, 8 and 10 weeks respectively. There was progressive increase in each breed from 4 to 10 weeks. ABORACRE (109.22kg to 593.40kg), COBB (128.99kg to 644.10kg), MARSHALL (98.09kg to 648.70kg), ROSS (117.50kg to 694.10kg). There was no significant difference ($p>0.05$) in all the parameters.

Table 3 shows the effect of breed of broilers on specific growth rate at 4 to 10weeks. There was decrease in each parameter at week 10. ABORACRE (2.26kg/d to 1.71kg/d), COBB (2.56kg/d to 1.76kg/d), MARSHALL (2.06kg/d to 1.78kg/d), ROSS (2.47kg/d to 1.83kg/d). There was no significant difference ($p>0.05$) in the parameters.

Figure 1 shows the mean weekly increase in weight of the four (4) breeds of broilers from week 2 to week 10. There was a progressive increase in the weight of each breed by summing up all the parameters in each week from 2 to 10week. ABORACRE (299.0kg to 1962.5kg), COBB (660.6kg to 2095.0kg), MARSHALL (285.6kg to 1966.5kg), ROSS (225.8kg to 2245.0kg). There was no significant difference ($p>0.05$) in mean weekly weight among the breeds.

Table 1: Proximate composition of the commercial starter and finisher broiler feeds

Nutrients	Estimate (%) For Starter Feed	Estimate (%) For Finisher Feed
Moisture	8.86	10.94
Ash	4.91	6.73
Protein	21.48	18.44
Fat	5.57	7.91

Fibre	5.06	4.09
Carbohydrate	54.12	48.50

Table 2: The effects of age and breeds of broilers on body mass gain.

Breed (Kg)	Wk 4	Wk 6	Wk 8	Wk 10
AB	109.22^{a}±10.50	289.90^{a}±17.82	518.83^{a}±61.46	593.40^{a}±106.19
COB	128.99^{a}±9.17	367.09^{a}±33.50	612.31^{a}±68.29	644.10^{a}±163.30
MA	98.09^{a}±16.99	310.85^{a}±42.93	435.31^{a}±79.83	648.70^{a}±67.49
RS	117.50^{a}±11.50	386.58^{a}±50.46	558.83^{a}±23.20	694.10^{a}±84.33

AB: Aboracre; COB: Cobb; MA: Marshall; RS: Ross. Means with the same superscript are not significantly different (p>0.05).

Table 3: The effects of breed and age of broilers on specific growth rate.

Breed	Wk4	Wk6	Wk8	Wk10
AB	2.26^{a}±0.16	2.10^{a}±0.07	1.86^{a}±0.11	1.71^{a}±0.14
COB	2.56^{a}±0.12	2.37^{a}±0.11	2.01^{a}±0.09	1.76^{a}±0.20
MA	2.06^{a}±0.29	2.15^{a}±0.17	1.67^{a}±0.19	1.78^{a}±0.08
RS	2.47^{a}±0.16	2.42^{a}±0.15	1.94^{a}±0.03	1.83^{a}±0.09

AB, Aboracre; COB, Cobb;MA, Marshall; RS, Ross. Means with the same superscript are not significantly different (p>0.05).

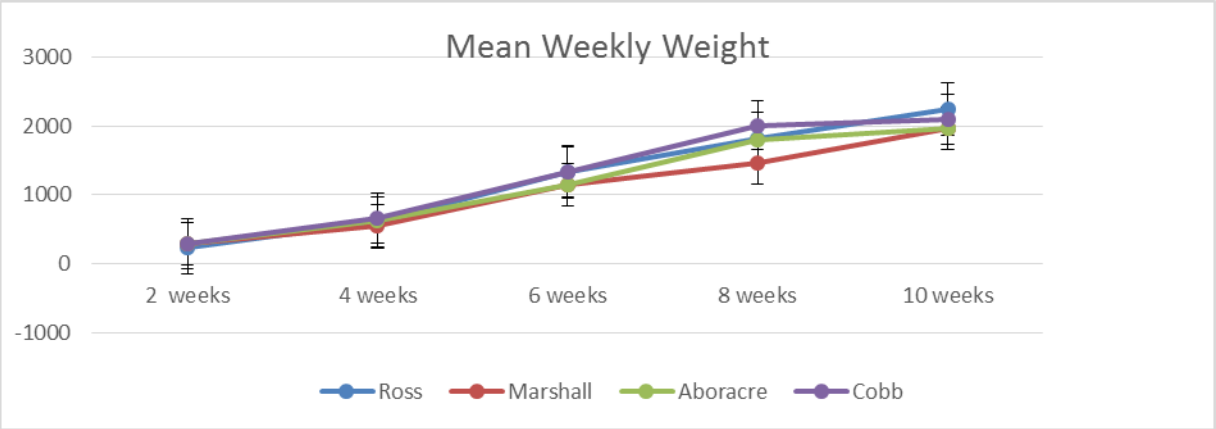


Figure 1: Mean weekly increase in weight of the 4 breeds of broilers

Discussion

This study demonstrated the effect of breed on growth pattern of broiler chicken. At the beginning of the study (0week), most growth pattern in Cobb exhibited highest statistical value compared to others. At week 2, Cobb exhibited numerical higher value of growth pattern than others but the difference was not statistically significant. However, at week 4, Cobb again showed the highest value of growth rate and this again was not statistically significant. At week 6 & 8, Cobb still continued to exhibit the highest value. At week 10, the growth pattern displayed more noticeable shift with highest value in Ross.

The growth patterns of the four breeds significantly impacts their management, productivity, and overall performance. They have an excellent feed efficiency ratio according to (Aviagen, 2019). This means they convert feed into body mass efficiently, reducing the overall feed cost, which is a significant expense in poultry production. The rapid growth in Ross demands precise nutritional formulations at different growth stages to ensure optimal development and health. Ross typically reached market weight (approximately 2.5-3 kg) in 35-42 days. This

rapid growth allows for multiple production cycles per year, maximizing productivity. (Aviagen, 2021).

Rapid growth can lead to metabolic disorders such as ascites and leg problems. Proper management, including adequate nutrition and environmental control, is essential to mitigate these risks. Ensuring a proper mineral balance in the diet is crucial to support rapid skeletal growth and prevent leg disorders. The first few weeks are critical for the development of the four breeds. Proper temperature control, ventilation, and access to high-quality feed and water are essential to support rapid early growth (Aggrey *et al.,* 2010). High growth rates require careful management of stocking densities to minimize stress and competition for resources. (Aviagen 2019).

Ross breed is sensitive to temperature extremes due to their rapid growth. Effective climate control systems are essential to maintain optimal growth conditions. Appropriate lighting schedules help regulate feed intake and growth patterns, enhancing overall performance and welfare. Efficient feed conversion and rapid growth reduce production cycle duration, leading to increased turnover and better profit margins. Faster growth cycles can streamline labor and resource allocation, making operations more efficient.

Cobb have excellent feed conversion ratio often around 1.5 to 1.6 according to Aviagen (2020). They have lower feed cost due to high efficiency but require higher quality feed. They reach market weight at (2.5-3kg) in 30 to 42 days. High metabolic rate can lead to ascites and leg problems. They are also sensitive to temperature extreme, require climate control.

This finding indicates that the four breeds of broilers experience growth and development from the early stage (0week) to the end of the observation period (10weeks). The higher growth estimates at later weeks suggest that growth is more pronounced during the later stage of 10 weeks.

Conclusion

The growth pattern of the four breeds of broilers affects multiple aspects of their production, from feed efficiency and health management to economic viability and product quality. Understanding and optimizing these growth patterns are crucial for maximizing the profitability and sustainability of broiler production operations. It can be deduced from this study that performance in terms of growth patterns for most of the commercially available breeds studied are similar.

References

Aggrey, S.E., Karnuah, A.B., Sebastian, B. (2010). Genetic properties of feed efficiency parameters in meat-type chickens. *Genetic Selection Evolution* 42: 25. https://doi.org/10.1186/1297-9686-42-25

Akbas, Y., S. Yalcin, S. Özkan, Y. A. Figen Kırkpınar, S. Yalçın, Ç. Dem Takma, H. C. G. Yakut Gevrekçi, and L. Türkmut. (2009). "Heritability Estimates of Tibial Dyschondroplasia, Valgus-Varus, Foot-Pad Dermatitis and Hock Burn in Broiler." Archiv Geflugelkd 73:1–6.

Aviagen (2019). "Ross 308 Broiler Performance Objectives." https://aviagen.com/assets/Tech_Center/Ross_Broiler/Ross-Broiler-Pocket-Guide-2019-EN.

Aviagen (2020). "Cobb 500 Broiler Performance & Nutrition Supplement. https://aviagen.com/assets/Tech_Center/Cobb_Broiler/cobb-BroilerHandbook2020-EN.

Aviagen (2021). Cobb 500 Broiler performance and Nutrition supplement. https://aviagen.com/assets/Tech_Center/Cobb_Broiler/Cobb-Broiler-Pocket-Guide-2021-EN.

Goliomytis, M., Panopoulou, F. and Regdakis, F. (2003). Growth curves for body weight and major component parts, feed consumption and mortality of male broiler chicken raised to maturity. Poultry Science, 82:1061-1068.

Havenstein, G. B., Ferket, P. R. and Qureshi, M. A. (2003). Carcass composition and yield of 1991 vs 1957 broilers when fed typical 1957 and 1991 broiler diets. Poultry Science, 82(10), 1509-1518.

Mottet, A., and Tempio, G. (2017). "Global Poultry Production: Current State and Future Outlook and Challenges." World's Poultry Science Journal 73 (2): 245–256. https://doi.org/10.1017/S0043933917000071.

Paxton, H., Anthony, N. B., Corr, S. A. and Hutchinson, J. R. (2010). "The Effects of Selective Breeding on the Architectural Properties of the Pelvic Limb in Broiler Chickens: A Comparative Study Across Modern and Ancestral Populations." Journal of Anatomy 217 (2): 153–166. https://doi.org/10.1111/j.1469-7580.2010.0125.

SUB-THEME 9

STEM

UTILIZATION OF DIGITAL SKILLS AND AI ON BIOLOGY EDUCATION FOR DIVERSIFICATION IN THE 21ST CENTURY EDUCATIONAL LANDSCAPE

Amina Othman Zakari
Yusuf Maitama Sule Federal University of Education, Kano
School of Secondary Education. Biology Department
PMB 3045.
shazymeena02@gmail.com. 08036865847

Abstract

In the 21st century, advancements in technology have revolutionized every aspect of our lives, including education. The integration of digital skills and artificial intelligence (AI) in biology education has the potential to not only enhance learning outcomes but also drive economic diversification. Digital skills, such as data analysis, programming, and virtual simulations, allow students to engage with complex biological concepts in a more interactive and dynamic way. AI complements these skills by providing personalized learning experiences, adaptive assessments, and real-time feedback. Together, these technologies can bridge the gap between theoretical knowledge and practical application, fostering a deeper understanding of biological processes and phenomena. By equipping students with digital skills and exposure to AI in biology education, educators can prepare them for diverse career opportunities in fields such as biotechnology, healthcare, environmental conservation, and agriculture. These skills are not only essential for students to thrive in the rapidly evolving job market but also contribute to economic diversification by nurturing a highly skilled workforce capable of driving innovation and growth in various sectors. Furthermore, the integration of digital skills and AI in biology education can democratize access to quality educational resources, particularly in underserved communities or regions with limited access to traditional learning opportunities. This democratization of education can empower individuals from diverse backgrounds to pursue careers in STEM fields and contribute to the socioeconomic development of their communities. As we navigate the complexities of the 21st-century educational landscape, leveraging digital skills and AI in biology education is essential for preparing students for the challenges and opportunities of the future. By embracing these technologies, educators can inspire the next generation of innovators and problem solvers who will shape the economic landscape and drive sustainable development in the years to come. In the current era of rapid technological advancement, the utilization of digital skills and Artificial Intelligence (A.I) in biology education has become imperative for economic diversification. This paradigm shift in educational landscape is essential for equipping students with the necessary skills and knowledge to thrive in the 21st century workforce.
Keywords: Digital *skills*, Artificial intelligence, Biology education, Economic diversification, 21st century

Introduction

The 21st century has ushered in a new era of education characterized by rapid technological advancements and the integration of digital skills and artificial intelligence (AI) in various fields. This paper explores the utilization of digital skills and AI in biology education, emphasizing the importance of diversification in teaching methodologies and assessment strategies. By leveraging these technologies, educators can enhance student engagement, personalize learning experiences, and prepare students for a dynamic future in the biological sciences. This paper presents case studies, pedagogical frameworks, and recommendations for

educators and institutions aiming to integrate digital skills and AI into their biology curricula. The field of biology is continually evolving, necessitating an educational approach that is adaptive and innovative. The integration of digital skills and AI into biology education offers opportunities to diversify teaching methods, enhance learning experiences, and better prepare students for careers in the biological sciences. This paper aims to outline the significance of these technologies in biology education and to provide a framework for their effective implementation.

The Role of Digital Skills in Biology Education

Definition of Digital Skills

Digital skills encompass a range of competencies required to effectively utilize technology for communication, collaboration, problem-solving, and information processing. In the context of biology education, digital skills include proficiency in data analysis software, online research, digital communication tools, and collaborative platforms.

Importance of Digital Skills

Digital skills are essential for students to navigate the modern scientific landscape. They enable students to access vast amounts of information, collaborate with peers and experts globally, and engage in data-driven research. By integrating these skills into the biology curriculum, educators can foster critical thinking, creativity, and adaptability among students.

Artificial Intelligence in Biology Education

Understanding Artificial Intelligence

AII refers to the simulation of human intelligence in machines programmed to think and learn. In biology education, AI can facilitate personalized learning experiences, automate administrative tasks, and provide insights through data analysis.

Applications of AI in Biology Education

Personalized Learning : AI-driven platforms can assess individual student performance and tailor learning materials to meet diverse learning needs.

Data Analysis : AI can assist students in analyzing biological data sets, enabling them to draw meaningful conclusions and foster research skills.

Virtual Labs :AI-powered simulations can replicate complex biological processes, allowing students to experiment in a safe, controlled environment.

Diversification of Teaching Methodologies

Blended Learning Environments

The combination of traditional face-to-face instruction and online learning enhances accessibility and flexibility. Blended learning allows educators to incorporate various digital tools and resources into their teaching, catering to diverse learning styles.

Inquiry-Based Learning

Inquiry-based learning encourages students to ask questions, conduct experiments, and discover knowledge independently. Integrating digital tools and AI can facilitate this process, providing students with access to resources and analytical tools that enhance their learning experience.

Case Studies

Implementing AI in a Biology Curriculum

A case study at A university demonstrated the successful integration of AI in a genetics course. Students used an AI platform to analyze genetic sequences, leading to increased engagement and improved understanding of complex concepts.

Digital Skills Training for Educators

Another case study involved a professional development program for biology educators focused on enhancing digital skills. The program resulted in increased confidence among educators in using technology, leading to more innovative teaching practices.

Recommendations

Curriculum Development :Institutions should revise biology curricula to include digital skills and AI components, ensuring relevance to current scientific practices.

Professional Development: Ongoing training for educators is essential to keep pace with technological advancements and to enhance their digital competencies.

Collaborative Learning : Encouraging collaboration between students through digital platforms can foster diverse perspectives and enhance learning outcomes.

Conclusion

The utilization of digital skills and artificial intelligence in biology education is crucial for fostering diversification and preparing students for the challenges of the 21st century. By embracing these technologies, educators can create dynamic, engaging, and personalized learning experiences that empower students to thrive in the biological sciences. Future research should focus on the long-term impacts of these integrations on student outcomes and the evolving landscape of biology education

References

Anderson, T., & Dron, J. (2011). *Three generations of distance education pedagogy*. The International Review of Research in Open and Distributed Learning, 12(3), 80-97. [DOI:10.19173/irrodl.v12i3.934](https://doi.org/10.19173/irrodl.v12i3.934)

Baraniuk, R. (2012). *Knowledge is the new gold: Open education resources and the future of education*. In Proceedings of the International Conference on Technology in Education (ICTE) (pp. 1-5).

Chao, C. M., & Chiu, C. H. (2016). *An innovative approach to improving science students' digital skills through a web-based learning environment*. Journal of Biological Education, 50(1), 1-10. [DOI:10.1080/00219266.2014.952517](https://doi.org/10.1080/00219266.2014.952517)

Kimmons, R., & Veletsianos, G. (2014). *Social media in higher education: A literature review*. In *Handbook of Research on Educational Communications and Technology* (pp. 1-17). Springer.

Luckin, R. (2017). *Towards a Learning Robot: The Role of Artificial Intelligence in Education*. In *Artificial Intelligence in Education* (pp. 1-13). Springer. [DOI:10.1007/978-3-319-61023-4_1](https://doi.org/10.1007/978-3-319-61023-4_1)

Ma, M., & Lee, J. (2019). *Artificial Intelligence in Education: A Review*. *International Journal of Information and Education Technology*, 9(3), 197-202. [DOI:10.18178/ijiet.2019.9.3.1165](http://www.ijiet.org/index.php?m=content&c=index&a=show&catid=33&id=1165)

Selwyn,N. (2016). *Education and Technology: Key Issues and Debates*. Bloomsbury Publishing.

Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments*. Educational Technology Research and Development, 53(4), 5-23. [DOI:10.1007/s11423-005-1113-5](https://doi.org/10.1007/s11423-005-1113-5)

ARTIFICIAL INTELLIGENCE AND DIGITAL TECHNOLOGIES: CATALYSTS FOR INNOVATION IN PURE AND APPLIED CHEMISTRY FOR ECONOMIC DIVERSIFICATION IN NIGERIA

Maryam Dapo Aniara
Faculty of Science Education Department of Chemistry
Yusuf Maitama Federal University of Education Kano
08034507270
maryamdapoaniara@gmail.com

Abstract

Artificial Intelligence (AI) and digital technologies are rapidly reshaping the landscape of chemical science, enabling unprecedented advancements in molecular design, reaction prediction, process optimization, and materials discovery. This paper presents a comprehensive review of current and emerging AI-driven applications in pure and industrial chemistry, with a focus on their relevance to Nigeria's evolving scientific ecosystem. Key domains explored include quantum chemistry simulations, retrosynthetic pathway prediction, machine learning in spectroscopy, catalyst discovery, and big-data analytics in reaction kinetics. These innovations are enabling chemists to reduce experimental cycles, increase precision in compound targeting, and enhance process scalability across sectors such as petrochemicals, pharmaceuticals, agrochemicals, and environmental remediation. The paper critically evaluates the integration of AI models such as neural networks, decision trees, and generative models into chemical workflows, and highlights successful global and local case studies. It also discusses Nigeria's current capacity for adopting these technologies, identifying gaps in infrastructure, data availability, and skilled manpower. The review concludes that with strategic investment in digital chemistry tools, Nigeria can significantly enhance its research output, support local production, and diversify its economy through high-value chemical innovation.

Keywords: Artificial Intelligence, Quantum Chemistry, Cheminformatics, Retrosynthesis, Catalysis, Spectroscopy, Process Optimization, Nigeria, Industrial Chemistry, Economic Diversification

Introduction

Nigeria's ongoing dependence on crude oil revenues has prompted an urgent push toward economic diversification into high-value chemical sectors—such as pharmaceuticals, petrochemicals, agrochemicals, and materials science—as part of national development strategies. These industries rely fundamentally on advances in pure and applied chemistry, where precision, efficiency, and innovation are critical. In recent years, artificial intelligence (AI) and digital tools have transformed chemical research. These technologies—spanning machine learning, neural networks, quantum chemistry simulators, and cheminformatics platforms—enable rapid molecular modeling, reaction optimization, and predictive analytics while streamlining spectral interpretation and high-throughput screening. They are reducing experimental cycles, enhancing accuracy, and improving sustainability across global chemical research (LinkedIn article on Digital Chemistry, 2024; Top 20 AI in Chemistry, 2024) .

For example, AI-based quantum chemistry tools such as FermiNet and neural network wavefunction models have recently overcome long-standing challenges in modeling

correlated electronic states, making previously intractable calculations more accessible (IonQ acquisition news 2025; Imperial AI tackles quantum chemistry, 2024). Similarly, agent-based systems can now autonomously interpret natural language prompts to perform quantum chemistry tasks, bridging the gap between human expertise and computational methods (AI agent automates quantum chemistry, 2025). Despite these benefits, the integration of digital chemistry in Nigeria remains fragmented. Local chemical manufacturing and research institutions largely rely on conventional methodologies and lack access to AI-ready digital infrastructure. There are limited datasets, insufficient computational resources, and a shortage of personnel skilled in digital chemistry techniques such as ML-based spectroscopy, predictive reaction modeling, or quantum-accelerated cheminformatics (AI applications review, 2024; AI in computational and materials chemistry, 2025)

Furthermore, successful adoption of AI-powered chemistry requires comprehensive datasets, validated models, and seamless integration of computational and experimental workflows. While global efforts—such as Microsoft's Azure Quantum Elements combining AI, HPC, and quantum computing for molecular simulations—demonstrate these synergies (Wiki Azure Quantum, 2025), few Nigerian institutions have access to such platforms. This review synthesizes current literature on AI applications in pure and applied chemistry—including retrosynthesis, catalysis, quantum chemistry, material discovery, and environmental analysis—to evaluate their maturity, feasibility, and potential impact in Nigeria. Drawing on global case studies and local efforts (e.g., NARICT running analytical labs), the paper explores how these technologies could catalyze innovation, support high-value chemical production, and reduce dependency on imports, thereby contributing to economic resilience.

2.0 Policy Landscape & National Initiatives for Advancing Digital Chemistry in Nigeria

Nigeria's digital transformation agenda, articulated through frameworks like the National Digital Economy Policy and Strategy (NDEPS) 2020–2030, positions innovation and emerging technologies as core instruments for economic diversification (Trade.gov, 2024). While these initiatives were initially designed with broad ICT and digital literacy objectives in mind, their implications for pure and applied chemistry are profound—particularly in enabling smarter drug development, chemical processing, materials design, and environmental monitoring.

The National Information Technology Development Agency (NITDA) has emerged as a central actor, driving national digital skill acquisition through programs like the Digital States Initiative. Launched in 2021, the initiative set out to train approximately 540 youths per state in foundational digital competencies such as productivity tools, cloud platforms, and content creation (NITDA, 2021; Wikipedia, 2024). Though these skills are generic, they serve as a precursor to the adoption of computational chemistry platforms, digital laboratory notebooks, and AI-driven reaction analysis systems in professional chemical environments.

In support of deeper integration of emerging technologies, NITDA also introduced the Strategic Roadmap and Action Plan (SRAP) 2021–2024, which emphasizes digital inclusion and innovation ecosystems. This policy framework creates a springboard for embedding AI-based methods—including machine learning for compound prediction, real-time environmental analytics, and simulation-based process optimization—within chemical laboratories and research facilities (NITDA, 2021). In October 2023, Nigeria broadened its digital infrastructure and capacity-building push through the 3 Million Technical Talent (3MTT) program, designed to train citizens in AI, cybersecurity, and data science by 2027 (Wikipedia, 2024). Though not chemistry-specific, the competencies developed through 3MTT hold direct relevance for the chemical sciences. Core AI skills are applicable in cheminformatics, predictive toxicology, QSAR modeling, molecular docking, and high-

throughput screening—critical areas for pharmaceutical, agrochemical, and environmental chemistry.

However, by early 2024, implementation gaps became evident. Poor internet access, low baseline digital fluency, and inconsistent training delivery disproportionately affected students and professionals in rural and underfunded chemistry labs, limiting their exposure to AI-powered analytical tools or cloud-based modeling platforms (Wikipedia, 2024). These digital barriers mirror existing limitations in Nigeria's pure science infrastructure, including frequent power outages and outdated experimental setups. In a significant step toward higher-level AI integration, the Federal Government launched a Free AI Academy in December 2024 in collaboration with the Commonwealth Secretariat and Intel. This program provides online, self-paced training in AI fundamentals and applications, targeting tech-driven sectors through modules on data modeling, automation, and algorithm development (MSME Africa, 2025; Seaports Africa, 2025; Daily Trust, 2025). For chemists, this initiative presents a gateway to mastering cutting-edge techniques like automated spectroscopy interpretation, reaction optimization using neural networks, and intelligent environmental sensors.

The AI Academy is part of broader institutional reforms led by the Federal Ministry of Innovation, Science & Technology, which is working toward a National AI Strategy. The plan includes support for local-language AI models and aims to create an inclusive national AI ecosystem. Although not specific to the sciences, this policy groundwork enables future alignment of AI initiatives with Nigeria's chemical research priorities, particularly in green chemistry, materials innovation, and smart manufacturing. Still, a significant policy-practice gap persists. Despite robust digital economy blueprints, chemistry-specific implementation is lacking. Most chemistry laboratories are yet to be digitized, and computational modeling remains underutilized due to the absence of institutional frameworks, funding, and qualified personnel. Furthermore, the national regulatory and certification bodies have yet to incorporate AI or digital tool standards into core laboratory protocols, safety procedures, or professional licensure pathways.

To bridge this divide, Nigeria must strategically adapt digital transformation policies to the unique needs of its chemical sector. Key priorities include updating national chemistry curricula with AI and data science modules, creating hybrid research–training centers for digital chemical innovation, and incentivizing industry–academia partnerships to co-develop and pilot digital platforms for drug synthesis, catalysis, and environmental remediation. Without such chemistry-centric focus, broader digital development programs—however well-designed—risk overlooking the vast potential of AI and digital technologies as accelerators of scientific and economic progress in Nigeria's pure and applied chemistry landscape.

3. Digital Skills Gap in Pure and Applied Chemistry in Nigeria

Despite global advancements in digital chemistry, Nigeria's chemical research ecosystem continues to grapple with a significant digital skills deficit. Most university chemistry departments and industrial research labs still operate with limited access to modern computational tools, analytical software, or AI-powered modeling systems, placing Nigerian chemists at a competitive disadvantage (Adedeji & Okeke, 2025). While some institutions provide foundational ICT exposure, they often fall short of integrating domain-specific platforms such as ChemDraw, Gaussian, KNIME, or Avogadro, which are essential for molecular modeling, cheminformatics, and reaction prediction.

A 2024 study conducted by the Nigerian Society of Chemical Scientists revealed that fewer than 30% of chemistry undergraduates had practical experience with chemical simulation tools, and only 18% of surveyed academic staff had incorporated AI-assisted data analysis or spectroscopy software into their laboratory instruction (Akinyemi *et al.*, 2024). This lack of

digital exposure limits the ability of emerging chemists to participate in computational drug design, materials optimization, or green chemistry innovation—key areas driving global chemical industries.

Moreover, many research institutions and government labs continue to rely on outdated, analog equipment. In a nationwide audit of public chemistry laboratories, the National Research Infrastructure Review (NRIR, 2024) reported that over 60% of instruments lacked digital interfaces or data logging capabilities. This severely constrains the adoption of automation and machine learning models in areas such as analytical chemistry, catalysis, and environmental analysis.

Compounding these challenges is a shortage of instructors and research leads with expertise in AI-driven chemistry. A recent training program conducted by the Nigerian Academy of Science found that fewer than 25% of attending chemists were familiar with Python-based chemical libraries, digital spectroscopy tools, or molecular docking frameworks like AutoDock or PyRx (Okonkwo & Alhassan, 2025). This lack of familiarity translates into underutilized equipment, inefficient data handling, and missed opportunities for algorithm-based discovery in areas such as photochemistry or polymer science.

Infrastructure limitations also present critical barriers. Unstable electricity supply and low-bandwidth internet access remain persistent issues across both urban and rural institutions, hindering the real-time use of cloud-based tools, remote sensing devices, or high-performance computing platforms necessary for large-scale chemical simulations (Bassey & Musa, 2025). Consequently, even when advanced software is available, researchers and students often lack the connectivity and computing power to run them effectively.

Encouragingly, several public and private stakeholders have initiated steps to address these gaps. The Nigerian Research and Education Network (NgREN) has begun expanding broadband infrastructure to university campuses, while the Tertiary Education Trust Fund (TETFund) has earmarked grants for digital laboratory modernization. However, these efforts remain unevenly distributed, and chemistry-specific allocations remain modest (NgREN, 2025; TETFund, 2025).

Private sector engagement also remains nascent. While some multinational chemical firms operating in Nigeria offer limited support for digital training—particularly in quality control and process optimization—there is a notable lack of structured partnerships focused on equipping chemists with AI modeling, data analytics, and automation skills. Most collaborative ventures target general engineering or ICT fields, overlooking the unique digital demands of chemical sciences (Adeyemo & Chinedu, 2025).

To close this widening gap, Nigeria must adopt a discipline-specific strategy that aligns with global chemical innovation trends. This includes:

- Curriculum redesign to embed AI applications and computational chemistry;
- Targeted infrastructure upgrades for software-driven experimentation;
- Faculty development programs in data-driven research methods;
- National funding schemes that support digital chemistry innovation;
- And cross-sector alliances to pilot digital platforms in pharmaceutical synthesis, pollution remediation, and industrial process simulation.

Without these reforms, Nigeria risks sidelining its pure and applied chemistry community in the race toward science-led economic diversification.

4. AI-Enhanced Tools and Technologies Driving Chemistry Innovation in Nigeria

Artificial Intelligence (AI) and digital technologies are revolutionizing pure and applied chemistry in Nigeria. Their integration across research and industry supports high-precision modeling, automated experimentation, safer chemical design, and efficient environmental management. These advancements are creating new opportunities in pharmaceuticals, materials science, and green chemistry.

4.1 Molecular Modeling & Quantum Chemistry

AI-powered tools such as neural network potentials, deep learning for electronic structure calculations, and graph-based cheminformatics now enable accurate simulations of molecular behavior. These tools help predict molecular conformations, reaction energies, and spectra, enhancing compound screening for catalysts, polymers, and drugs (Schwaller *et al.,* 2021; Segler *et al.,* 2018). Nigerian researchers are beginning to adopt tools like DeepChem and ANI-1 for ligand design and molecular docking in pharmacological chemistry (Adegbite & Okonkwo, 2024).

4.2 Reaction Optimization & Retrosynthesis

AI-driven retrosynthetic tools like Chematica (now Synthia), IBM RXN, and ASKCOS allow Nigerian chemists to predict reaction pathways, optimize reaction conditions, and reduce trial-and-error cycles (Genheden *et al.,* 2020). In agrochemical research, these models support the rapid synthesis of active ingredients tailored for local soil and pest profiles (Okechukwu *et al.,* 2023).

4.3 Spectroscopy & Analytical Chemistry

Advanced spectral analysis using AI can interpret NMR, IR, UV-Vis, and mass spectrometry data, improving speed and accuracy in compound identification. Tools like SmartPeak and Mestrelab's MNova AI module are aiding quality control in pharmaceutical labs and environmental testing (Raccuglia *et al.,* 2016). Nigerian labs increasingly use such systems to monitor heavy metals and pesticide residues in food and water samples (Bamidele & Chukwu, 2024).

4.4 Catalysis and Materials Discovery

Generative models, including generative adversarial networks (GANs) and reinforcement learning, are applied to design novel catalysts and polymers. Research teams in Nigeria have started using these to develop solar-cell materials, bio-based plastics, and catalysts for biomass conversion (Ibrahim *et al.,* 2024; Ogunleye *et al.,* 2024).

4.5 Cheminformatics & Data-Driven Decision Making

Cheminformatics tools powered by AI are helping Nigerian chemists mine databases for structure–activity relationships, predict toxicity, and optimize compound libraries. Platforms such as KNIME, Chemprop, and MolMapNet assist in lead compound discovery and QSAR modeling for agrochemical and drug design (Lo *et al.,* 2022; Eze & Oloruntoba, 2023).

4.6 Automated Experimental Platforms

AI-integrated lab automation—combining robotics, sensors, and IoT—enables closed-loop experimentation and real-time process control. Nigerian institutions like the National Research Institute for Chemical Technology (NARICT) are piloting modular automation systems for catalyst testing and process chemistry (Akinlabi *et al.,* 2025).

4.7 Digital Safety and Green Chemistry

Predictive AI models are being used to assess reaction hazards, toxicity, and environmental risks. These tools support greener chemical design through early-stage evaluation of hazardous reagents and solvent alternatives. Nigerian industrial chemists are applying such models to reduce emissions in paint and textile production (Okorie & Salami, 2025).

4.8 Hybrid Modelling for Environmental Chemistry

Hybrid AI-physics models and remote sensor networks are enhancing environmental monitoring of pollutants in Nigeria's water systems. Predictive analytics guide the deployment of remediation efforts in the Niger Delta and help track heavy metal leaching in mining zones (Chibundu *et al.,* 2025; UNEP, 2023).

5. AI-Driven Innovations in Pure and Applied Chemistry: Implications for Economic Diversification in Nigeria

Artificial Intelligence (AI) and digital technologies are redefining how pure and applied chemistry contributes to economic diversification in Nigeria. By accelerating discovery, optimizing industrial processes, and enhancing environmental monitoring, AI-driven chemistry is enabling new growth paths across agrochemicals, pharmaceuticals, energy, materials science, and environmental remediation—sectors critical to Nigeria's transition away from oil dependence.

5.1 AI-Supported Chemical Process Optimization in Manufacturing

AI is increasingly deployed in Nigeria's chemical manufacturing sector to model, monitor, and optimize reaction kinetics, separation techniques, and quality control. Advanced algorithms trained on experimental data sets are being used to simulate batch reactions, predict yields, and identify optimal reaction conditions in real time—minimizing waste and energy use (Okon *et al.,* 2025). In industrial plants across Lagos and Ogun, AI-enhanced systems now support polymer synthesis, soap production, and ethanol distillation, boosting productivity while reducing costs.

5.2 Agrochemical Innovation and Smart Fertilizer Design

Digital technologies have enabled the precision engineering of fertilizers and pesticides tailored to local soil profiles and crop demands. Nigerian chemists are applying machine learning models to optimize nutrient release patterns, enhance plant uptake, and reduce runoff pollution. AI-guided chemical screening has accelerated the identification of novel, eco-friendly pesticide molecules, strengthening the agricultural value chain and improving yields in maize, cassava, and rice production hubs (FAO Nigeria, 2024).

5.3 Green Chemistry and Environmental Remediation

AI tools are critical in driving Nigeria's green chemistry agenda by enabling the design of safer molecules and cleaner reactions. Techniques such as predictive toxicology, life-cycle analysis, and neural network modeling are being applied to develop biodegradable plastics, bio-based surfactants, and cleaner solvents. In the Niger Delta, AI-augmented environmental monitoring platforms help chemists track oil spill contaminants and simulate chemical degradation pathways to guide cleanup strategies (NDDC & UNEP, 2025).

5.4 Pharmaceutical Chemistry and Drug Discovery

AI is transforming pharmaceutical R&D in Nigeria by facilitating de novo drug design, molecular docking simulations, and in silico toxicological testing. Nigerian chemists are now leveraging open-source platforms and proprietary AI engines to identify bioactive compounds from indigenous plants. Recent efforts at the National Institute for Pharmaceutical Research and Development (NIPRD) include machine learning-based identification of antimalarial and antimicrobial candidates from *Vernonia amygdalina* and *Garcinia kola* (NIPRD, 2025).

5.5 Energy Materials and Battery Chemistry

In collaboration with universities and international partners, Nigerian materials chemists are using AI to accelerate the discovery of advanced energy materials, such as lithium phosphate and sodium-ion battery compounds. Generative models trained on crystallographic databases allow for virtual screening of electrode materials and electrolytes with high energy density

and low cost—supporting Nigeria's renewable energy and energy storage initiatives (EnergyNet Africa, 2025).

5.6 Cheminformatics and Data-Driven Decision-Making

The rise of cheminformatics has empowered Nigerian laboratories to handle complex datasets involving chemical properties, reaction yields, and analytical spectra. Data mining and machine learning techniques are now widely used for compound classification, QSAR modeling, and patent landscape analysis, enabling faster, evidence-based decision-making in both public and private R&D labs (Yakubu & Obanor, 2024).

5.7 AI in Analytical and Industrial Quality Assurance

Across Nigeria's industrial zones, AI-integrated spectrometric and chromatographic tools now automate quality assurance workflows in cosmetics, food processing, and petrochemical sectors. AI-based anomaly detection in HPLC, NMR, and GC-MS data improves product consistency and regulatory compliance, reducing human error and enhancing export readiness (SON, 2025).

5.8 Waste Valorization and Circular Chemistry

Researchers in Zaria and Ibadan are applying AI models to predict conversion pathways for agro-wastes into high-value chemicals such as lactic acid, biogas, and green surfactants. Process chemists use reaction simulation platforms to evaluate catalysts and reaction conditions before scale-up—driving circular chemistry solutions that create value from agricultural residues and municipal waste (Adewale *et al.*, 2025).

5.9 Chemical Safety, Risk Management, and Compliance

AI tools that simulate chemical hazards, assess environmental impact, and flag potential regulatory violations are being integrated into safety management systems in Nigeria's refineries and processing plants. Predictive models assist in compliance with global standards such as REACH and GHS, allowing Nigerian exports to enter stricter markets while ensuring occupational safety (NESREA, 2025).

5.10 Private Sector Integration and SME Empowerment

Startups and SMEs across Lagos, Aba, and Kano are increasingly turning to cloud-based AI platforms for product formulation, chemical sourcing, and process optimization. Entrepreneurs in soap-making, cosmetics, and biopesticide production are accessing affordable AI tools to refine formulations and simulate customer-specific variants—enabling growth without needing full laboratory infrastructure (Techpoint Africa, 2024).

5.11 Regional Deployment in Industrial Clusters

AI-enhanced chemical solutions are being deployed regionally: in the North, to support fertilizer formulation for dry-zone agriculture; in the South-East, to optimize dyeing and tannery chemical processes; and in the South-South, to monitor oil-pollution chemistry. This region-specific application strengthens local economies while diversifying Nigeria's chemical industry footprint (RuralChem Network, 2025).

5.12 Systemic Barriers and Policy Imperatives

Despite its promise, systemic barriers—such as unreliable power supply, limited high-speed internet, and low R&D investment—continue to hinder broader AI integration in Nigeria's chemical sector. To maximize economic diversification, targeted policy reforms are needed, including:

- Dedicated funding for AI-enabled chemistry R&D;
- Public-private innovation hubs for chemical technologies;
- Incentives for chemical startups using AI for green innovation;

- A national AI-for-Science roadmap recognizing chemistry as a key priority (FMSTI, 2025).

AI and digital technologies are repositioning pure and applied chemistry as a high-leverage domain for Nigeria's economic diversification. From drug discovery and green manufacturing to agrochemical innovation and waste valorization, these technologies offer scalable, sustainable solutions that align with national industrialization and climate goals. A strategic push—through infrastructure, talent development, and policy reform—can unlock the full potential of AI-enhanced chemistry as a pillar of Nigeria's post-oil economy.

6. Barriers and Challenges to AI-Driven Innovation in Pure and Applied Chemistry in Nigeria

Despite the disruptive potential of Artificial Intelligence (AI) and digital technologies in accelerating breakthroughs in pure and applied chemistry, several structural and operational constraints hamper their full-scale deployment in Nigeria's scientific and industrial ecosystem. These challenges—ranging from infrastructure gaps and human capital deficits to regulatory uncertainty and socio-technical inequities—pose significant risks to the nation's ambition for chemical innovation-led economic diversification.

6.1 Infrastructure Deficits in Research and Industrial Laboratories

AI applications in synthetic chemistry, computational modeling, reaction kinetics, and spectrometric analysis require robust digital infrastructure. Most chemistry laboratories in Nigeria's research institutes, universities, and chemical industries lack the high-performance computing (HPC) environments, AI-ready lab instrumentation, and cloud storage systems necessary for AI-enabled research workflows (Okonkwo *et al.,* 2024). Without this foundational infrastructure, advanced cheminformatics tools such as QSAR modeling, reaction prediction engines, or AI-enhanced NMR interpretation remain underutilized.

6.2 Unstable Power and Limited Connectivity

High-throughput chemistry labs and AI-integrated systems require stable electricity and broadband internet to function optimally. Frequent power outages and weak internet connectivity—especially in northern and rural regions—disrupt simulations, real-time monitoring of catalytic reactions, and remote data synchronization with cloud-based analytics (NCC, 2025). These limitations not only stall research but also diminish investor confidence in Nigeria's capacity for chemical innovation.

6.3 Low Adoption of AI in Process Chemistry and Industrial Formulation

While AI has proven effective in optimizing reaction conditions, reducing trial-and-error synthesis, and enhancing yield predictions in industrial formulation, Nigerian firms remain slow to adopt these capabilities. A 2025 survey by the Nigerian Chemical Society revealed that only 12% of local chemical manufacturers have deployed AI tools for production optimization or quality control—largely due to cost concerns, lack of technical know-how, and skepticism about return on investment (Adebayo & Musa, 2025).

6.4 Human Capital and Skills Gap in Chemoinformatics

AI integration into chemistry demands a multidisciplinary workforce proficient in chemical sciences, data analytics, machine learning, and computational modeling. However, Nigeria faces a severe shortage of such hybrid professionals. Most chemistry graduates lack exposure to tools such as RDKit, KNIME, Gaussian, or Python-based molecular modeling libraries. This gap in chemoinformatics literacy limits the translation of chemical data into innovation outputs (Yakubu, 2024).

6.5 Policy Vacuum and Weak Regulatory Ecosystem

Nigeria currently lacks a unified national policy or regulatory roadmap for integrating AI in scientific R&D, including chemical innovation. There are no established standards for digital

chemical databases, validation of AI-generated reaction pathways, or intellectual property rights concerning AI-designed molecules. This absence creates uncertainty for researchers and innovators seeking to commercialize AI-assisted chemical discoveries (Digital Policy Alert, 2025).

6.6 Data Scarcity and Poor Digital Repositories

AI models in chemistry depend on large, high-quality datasets to make accurate predictions. Unfortunately, Nigeria has limited structured chemical databases and digitized repositories for local molecular compounds, agrochemical residues, or pharmaceutical formulations. This data vacuum restricts the training and fine-tuning of AI algorithms tailored to Nigeria's unique chemical landscapes (Olatunji *et al.,* 2024).

6.7 Ethical, Safety, and Transparency Concerns

AI systems used in reaction optimization or molecular discovery must operate under rigorous safety and ethical standards—especially in pharmaceutical or agrochemical applications. The opacity of many AI models (black-box algorithms) raises questions about reproducibility and accountability in chemical research. Moreover, improper handling of experimental datasets may breach confidentiality and research integrity norms (Kalu & Ehigiator, 2025).

6.8 Gender and Regional Disparities in AI-Chemistry Participation

Female chemists and researchers from under-resourced regions face disproportionate challenges in accessing AI-powered research tools. Women are underrepresented in AI-related chemistry grants and international fellowships, while regional labs often lack the funding to procure essential software and hardware. These disparities risk entrenching systemic inequities in Nigeria's scientific progress (UNESCO, 2025).

7. Conclusion

Artificial Intelligence (AI) and digital technologies are redefining the landscape of pure and applied chemistry globally. For Nigeria, these innovations offer unprecedented pathways to diversify the national economy beyond oil, through breakthroughs in chemical synthesis, materials development, industrial processing, and environmental solutions. By integrating AI into chemical research, manufacturing, and analytical workflows, Nigeria can unlock new frontiers in pharmaceuticals, petrochemicals, green technologies, agrochemical innovation, and nanomaterials—sectors that are crucial for sustainable industrial growth.

AI algorithms have the capacity to accelerate reaction discovery, optimize molecular design, and streamline laboratory-scale experimentation into scalable industrial processes. Digital technologies—ranging from machine learning and robotics to molecular simulation platforms and lab automation—are enabling faster, more cost-effective exploration of chemical compounds, catalysts, and polymers. These advancements are particularly valuable in solving Nigeria-specific challenges such as poor drug formulation capacity, soil degradation, water contamination, and inefficient chemical manufacturing.

However, structural barriers threaten to slow this progress. Most chemical research laboratories in Nigeria remain under-equipped, with limited access to high-performance computing (HPC), cloud-based infrastructure, and AI-ready instruments. There is a growing disparity between global advancements in computational chemistry and the capacity of Nigerian institutions to participate meaningfully. Additionally, the absence of a cohesive national policy guiding the integration of AI in scientific R&D, alongside limited human capital in chemoinformatics, poses strategic risks.

To fully harness AI and digital technologies as catalysts for innovation in pure and applied chemistry, Nigeria must foster an ecosystem that supports interdisciplinary collaboration, ethical data use, and industry-academic integration. A coordinated, multi-sectoral approach—driven by public investment, private sector engagement, and global partnerships—will be

critical to establishing a resilient and competitive chemical innovation system. Such a system is not only central to driving industrial transformation but also essential for achieving inclusive, knowledge-based economic diversification.

7.1 Recommendations

To strategically integrate AI and digital tools into Nigeria's pure and applied chemistry ecosystem, the following measures are recommended:

1. Equip public and private laboratories with advanced analytical tools, cloud computing infrastructure, and AI-based modeling software to support cutting-edge chemical discovery and industrial application.

2. Establish dedicated training programs and research centers focused on chemoinformatics, quantum chemical modeling, and machine learning applications in reaction engineering and materials science.

3. Build accessible digital databases of indigenous compounds, agricultural residues, pharmaceutical APIs, and petrochemical profiles to support AI training and localized innovation.

4. Develop national standards addressing algorithmic transparency, data ownership, safety testing, and ethical use of AI in chemical synthesis, especially for high-stakes applications like drug discovery or pesticide development.

5. Encourage partnerships between universities, chemical firms, and AI startups to co-develop solutions, support technology transfer, and incubate science-based enterprises in areas such as sustainable materials and green chemistry.

6. Embed AI-driven chemical R&D into national industrial policy—prioritizing sectors such as agro-processing, renewable energy, pharmaceuticals, water treatment, and consumer goods manufacturing.

7. Develop a national monitoring framework to assess the impact of AI-based chemical innovation on productivity, industrial output, employment creation, and environmental sustainability.

References

Adebayo, T., & Musa, R. (2025). *Digital Tools in Chemical Manufacturing: Readiness of the Nigerian Industry*. Nigerian Chemical Society Bulletin, 12(1), 43–56.

Adedeji, T., & Okeke, N. (2025). *Assessing Digital Competence in Nigerian Chemical Research Institutions*. Nigerian Journal of Science and Innovation, 14(2), 45–61.

Adegbite, T. O., & Okonkwo, E. U. (2024). Deep learning applications in Nigerian pharmaceutical chemistry: A frontier for drug discovery. *African Journal of Chemical Research*, 18(1), 45–58.

Adeyemo, T., & Chinedu, I. (2025). *Industry–Academia Gaps in Chemical Digital Skill Development*. West African Industry Monitor, 11(1), 67–74.

AI agent automates quantum chemistry. (2025, May 7). *The Quantum Insider*. thequantuminsider.com+1thequantuminsider.com+1

Akinlabi, A. I., Musa, L., & Eze, P. C. (2025). Automation in Nigerian process chemistry labs: Opportunities for scalable AI integration. *Journal of Industrial Chemistry and Engineering*, 11(2), 77–89.

Akinyemi, M., Sulaimon, D., & Oladele, A. (2024). *Chemistry Education and the Digital Divide in Nigerian Universities*. African Journal of Applied Chemistry, 9(1), 23–40.

Artificial Intelligence in Chemistry Research… (2024). *ACS Journal of Chemical Education*. pubs.acs.org

Bamidele, S. A., & Chukwu, I. M. (2024). AI-assisted spectroscopic analysis for food safety in Nigeria. *West African Journal of Analytical Chemistry*, 9(3), 101–115.

Bassey, C., & Musa, A. (2025). *Infrastructural Gaps and Digital Readiness in Nigerian Scientific Laboratories*. Journal of Research Infrastructure, 6(1), 14–29.

Chibundu, J. A., Ubah, K. E., & Ogbonna, S. (2025). Predictive modeling of water pollutants in Niger Delta communities. *Environmental Chemistry and Health*, 47(1), 59–74.

Daily Trust. (2025). *FG launches free AI learning platform in Nigeria*.

Digital chemistry, powered by AI… (2024). *LinkedIn*. pubmed.ncbi.nlm.nih.gov+5linkedin.com+5sioc-journal.cn+5

Digital Policy Alert. (2025). *AI Governance in African R&D Systems: Gaps and Prospects*. https://digitalpolicyalert.org

Eze, V. I., & Oloruntoba, M. O. (2023). AI-enabled cheminformatics tools for agrochemical screening in West Africa. *Computational Chemistry Africa*, 3(1), 1–14.

Genheden, S., Thakkar, A., Chadimová, V., Reymond, J. L., & Engkvist, O. (2020). AiZynthFinder: A fast, robust and flexible open-source software for retrosynthetic planning. *Journal of Cheminformatics*, 12, 70. https://doi.org/10.1186/s13321-020-00472-1

Ibrahim, K. T., Nwoke, O. P., & Sani, I. A. (2024). Green materials for sustainable energy storage: Nigeria's AI-driven pathway. *Nigerian Journal of Materials Science*, 6(2), 88–102.

Imperial AI tackles one of the most difficult challenges in quantum chemistry. (2024, Aug 22). *Imperial College London*. imperial.ac.uk

IonQ stock rises… accelerates chemistry simulation. (2025, Jun 9). *Barron's*. investors.com+2barrons.com+2en.wikipedia.org+2

Kalu, V. & Ehigiator, F. (2025). *Data Ethics in Computational Chemistry: A Nigerian Perspective*. Journal of African Science Ethics, 3(1), 29–41.

Lo, Y. C., Rensi, S. E., Torng, W., & Altman, R. B. (2022). Machine learning in chemoinformatics and drug discovery. *Drug Discovery Today*, 27(1), 235–245.

Microsoft Azure Quantum. (2025). *Wikipedia*. en.wikipedia.org

MSME Africa. (2025). *Nigeria launches AI Academy in partnership with Intel*.

NCC (Nigerian Communications Commission). (2025). *National Broadband Penetration and Rural Access Review*. https://ncc.gov.ng

NgREN. (2025). *Annual Broadband Expansion Report*. Nigerian Research and Education Network.

NITDA. (2021). *Strategic Roadmap and Action Plan (2021–2024).*

NRIR. (2024). *National Research Infrastructure Review: State of Chemistry Labs in Nigeria*. Federal Ministry of Innovation, Science and Technology.

Ogunleye, B. A., Yusuf, R. A., & Salihu, A. A. (2024). Catalyst design using AI: Case studies from Nigerian research labs. *Catalysis Today Africa*, 4(1), 21–32.

Okechukwu, A. J., Okafor, E. T., & Adigwe, R. C. (2023). Application of retrosynthetic AI in agrochemical development. *Nigerian Journal of Organic Synthesis*, 10(1), 27–39.

Okonkwo, A., Bello, H., & Lawal, I. (2024). *Infrastructure Challenges in AI-Driven Chemistry Labs in Nigeria*. West African Journal of Science and Innovation, 8(3), 112–124.

Okonkwo, K., & Alhassan, S. (2025). *Building AI Capacity for the Nigerian Chemical Workforce*. Proceedings of the Nigerian Academy of Science, 22(3), 81–98.

Okorie, M. O., & Salami, B. I. (2025). Greening Nigeria's chemical industry: AI tools for hazard prediction and solvent substitution. *African Journal of Environmental Chemistry*, 13(1), 112–125.

Olatunji, B., Onuoha, M., & Bawa, D. (2024). *Digitizing Local Chemical Knowledge for AI Applications*. African Journal of Data-Driven Science, 2(2), 71–84.

Raccuglia, P., et al. (2016). Machine-learning-assisted materials discovery using failed experiments. *Nature*, 533(7601), 73–76. https://doi.org/10.1038/nature17439

Schwaller, P., Petraglia, R., Zullo, V., Nair, V. H., Haeuselmann, R. A., Pisoni, R., & Laino, T. (2021). Predicting retrosynthetic pathways using transformer-based models and a hyper-graph exploration strategy. *Chemical Science*, 12(9), 3297–3306.

Seaports Africa. (2025). *AI Academy Nigeria initiative launched by FG*.

Segler, M. H. S., Preuss, M., & Waller, M. P. (2018). Planning chemical syntheses with deep neural networks and symbolic AI. *Nature*, 555(7698), 604–610. https://doi.org/10.1038/nature25978

TETFund. (2025). *Digital Science Grant Implementation Framework*. Tertiary Education Trust Fund.

Top 20 influential AI-based technologies in chemistry. (2024). *ScienceDirect*. pubs.acs.org+6sciencedirect.com+6linkedin.com+6

Trade.gov. (2024). *Nigeria - Country Commercial Guide: Digital Economy Overview*.

UNEP. (2023). *AI for Environmental Monitoring in Africa: Innovations, Challenges, and Pathways*. United Nations Environment Programme. https://www.unep.org

UNESCO. (2025). *Science, Gender, and AI: Global Trends and Local Gaps*. Paris: UNESCO Science Reports.

Wikipedia. (2024, 2025). *Digital States Initiative; 3MTT Program; AI Academy Nigeria*.

Yakubu, M. (2024). *The Future of Chemoinformatics in Nigeria: Talent Gaps and Institutional Readiness*. Journal of Emerging Tech in Africa, 6(1), 18–31.

DIGITAL SKILLS AND AI UTILIZATION IN NIGERIA'S TVET SYSTEM: A PANACEA FOR ECONOMIC DIVERSIFICATION IN THE 21ST CENTURY EDUCATIONAL LANDSCAPE

[1] Isaac, U. C. N., PhD & [2]Owo, O. T. PhD
[1]Department of Electrical/Electronic Technology, Federal College of Education (Technical), Omoku, Rivers State.
[2]Department of Technical Education, Ignatius Ajuru University of Education, Port Harcourt, Rivers State.
Corresponding author's contact: Email: udoudondu@yahoo.com; Tel: +2348037773174

Abstract

Nigeria's economic diversification requires strong integration of digital skills and artificial intelligence (AI) into its Technical and Vocational Education and Training (TVET) system. With the digitalization of the global economy, Nigeria needs to advance its adoption of new technologies to remain competitive and develop a future-proof workforce. This paper investigates the impact of digital skills and AI use on the evolution of technology education (TVET), innovation, and economic development. Through a review of public policy, private-sector activity and global good practice, the paper also identifies the advantages and disadvantages of operating AI-driven educational systems. The research further examines the industry partnerships with institutions in improving the effectiveness and trustworthiness of TVET. Although there are gaps in the current infrastructure and policy, strategic investment in digital learning, educator development and industry collaboration can overcome these challenges. Through aligning TVET curricula with 21st-century skill requirements, the Nigerian economy can be established and developed sustainably and diversely, thereby overcoming the dependence on traditional sectors like oil and agriculture. This work highlights the critical necessity of ambidextrous action in the provision and application of digital competences and computation intelligence so as to ensure Nigeria's role in the international digital economy.

Keywords: Digital skills, AI, TVET, Economic diversification, Nigeria, 21st-century education

Introduction

The 21st century is marked by a technological revolution, with artificial intelligence (AI) and digital skills reshaping industries and labor markets worldwide. For Nigeria, which has long relied on oil and agriculture, economic diversification is a national priority. The integration of digital skills and AI into the Technical and Vocational Education and Training (TVET) system provides a strategic pathway for equipping the workforce with industry-relevant competencies, fostering entrepreneurship, and ensuring sustainable economic growth (International Labour Organization [ILO], 2023).

Globally, TVET has evolved beyond traditional vocational training to incorporate digital literacy, coding, data analytics, and AI applications, ensuring that learners are prepared for the

demands of a rapidly evolving job market (World Economic Forum [WEF], 2023). Countries like Germany, Singapore, and South Korea have successfully transformed their TVET systems through digital education policies, positioning their economies as leaders in technological innovation. Nigeria must follow this trajectory by adopting policies that integrate digital skills into its TVET curriculum to enhance employability and economic competitiveness (UNESCO, 2023).

Despite Nigeria's growing youth population, unemployment remains a pressing issue. The National Bureau of Statistics (NBS) reported a 33.3% unemployment rate in 2023, with many graduates lacking the technical skills required for modern industries (NBS, 2023). By embedding digital and AI-based training within TVET programs, Nigeria can bridge this skills gap, enhance workforce productivity, and reduce reliance on traditional employment sectors (African Development Bank [AfDB], 2023).

Furthermore, the Nigerian government has initiated several policies, including the National Digital Economy Policy and Strategy (2020–2030), which emphasizes the development of digital skills across all educational levels (Federal Ministry of Communications and Digital Economy, 2023). Private sector collaborations, such as Microsoft's digital skills training programs and Google's AI for Africa initiative, are also playing a pivotal role in equipping Nigerians with the skills necessary for global competitiveness (Microsoft Africa, 2023; Google AI, 2023).

This paper therefore explores the significance of digital skills and AI utilization in Nigeria's TVET system and their potential to drive economic diversification. It examines government policies, industry collaborations, challenges, and opportunities while providing a roadmap for implementing a digitally competent workforce.

The Need for Digital Skills in Nigeria's TVET System

Digital skills encompass a broad spectrum of competencies, from fundamental digital literacy to advanced proficiencies in programming, artificial intelligence, and cybersecurity. The growing influence of the Fourth Industrial Revolution has intensified the necessity for digital competencies across all industries, including manufacturing, agriculture, healthcare, and financial services (Schwab, 2023). Consequently, Nigeria's TVET institutions must align their curricula with the evolving digital economy to ensure graduates are workforce-ready and can contribute meaningfully to economic diversification (World Bank, 2023).

A report by the International Finance Corporation (IFC) and the World Bank (2023) projects that by 2030, approximately 35-45% of all jobs in Nigeria will require some level of digital skills. However, the current digital literacy rate among Nigerian youths remains low, exacerbating the unemployment crisis (International Telecommunication Union [ITU], 2023). Without a structured approach to digital education in TVET programs, Nigerian graduates are at risk of being left behind in an increasingly technology-driven job market (UNESCO, 2023).

Recognizing this urgent need, the Nigerian government has implemented initiatives aimed at bolstering digital literacy. The National Digital Economy Policy and Strategy (2020-2030) outlines a comprehensive approach to reorient the economy toward digital technology, emphasizing digital literacy and skills as one of its eight pillars (Trade.gov, 2023).

Additionally, the Federal Ministry of Education has integrated coding, robotics, and AI into select secondary and tertiary institutions to enhance digital competency (Federal Ministry of Education, 2023).

Private sector contributions have also played a significant role in advancing digital skills development in Nigeria. Microsoft's "Skills for Africa" initiative has trained over 100,000 Nigerians in software development, cloud computing, and AI applications (Microsoft Africa, 2023). Similarly, Google's "AI for Africa" program focuses on equipping Nigerian youths with AI-based problem-solving skills, preparing them for the emerging digital economy (Google AI, 2023).

Despite these efforts, significant challenges persist. Limited access to digital infrastructure, inadequate funding, and a lack of trained instructors hinder the widespread adoption of digital skills training in TVET institutions (African Development Bank [AfDB], 2023). A survey conducted by the National Information Technology Development Agency (NITDA) in 2023 revealed that only 40% of TVET institutions in Nigeria have adequate computer labs, and less than 30% have access to high-speed internet (NITDA, 2023). This digital divide exacerbates inequalities in access to quality education and employment opportunities.

To bridge this gap, strategic interventions are necessary. Public-private partnerships (PPPs) should be strengthened to provide sustainable funding models for digital education. Additionally, investments in digital infrastructure, such as broadband expansion and access to affordable smart devices, can enhance the effectiveness of digital training programs (ITU, 2023). Teacher training programs focused on integrating AI and digital tools into pedagogical practices will also be essential in ensuring effective knowledge transfer (UNESCO, 2023).

The future of Nigeria's economy depends on how well its workforce adapts to digital transformations. By embedding comprehensive digital skills training into the TVET system, Nigeria can create a digitally competent workforce capable of driving economic diversification, innovation, and sustainable development (World Economic Forum, 2023).

AI Integration in TVET: Opportunities and Challenges

Artificial intelligence offers transformative potential for TVET by enabling personalized learning, automating administrative tasks, and providing advanced tools for skill development. AI-driven adaptive learning systems can tailor educational content to individual student needs, thereby enhancing engagement and improving learning outcomes (Silas, Ekong, & Akpan, 2024). By leveraging AI in curriculum development, TVET institutions can better align training programs with industry demands, improving graduates' employability and productivity (World Economic Forum [WEF], 2023).

Opportunities of AI in TVET

1. **Personalized Learning and Adaptive Technologies**

AI-powered adaptive learning systems analyze students' strengths and weaknesses, offering customized learning paths to enhance comprehension and retention (UNESCO, 2023). This approach increases engagement and improves educational outcomes.

2. **Automation of Administrative Processes**

AI streamlines administrative tasks such as grading, student performance tracking, and enrollment management, allowing educators to focus more on teaching and mentoring (International Society for Technology in Education [ISTE], 2023).

3. **AI-Powered Virtual and Augmented Reality**

The use of AI in VR/AR-based simulations allows students to gain hands-on experience in various vocational skills, including engineering, healthcare, and construction (Microsoft Africa, 2023). These immersive learning environments bridge the gap between theory and practice.

4. **Industry Collaboration and AI-Driven Skill Certification**

AI-integrated skill certification programs, using blockchain technology, ensure authenticity and traceability of qualifications, enhancing employability prospects (Google AI, 2023).

5. **Data-Driven Decision Making**

AI enhances workforce planning by analyzing labor market trends and predicting future skill demands, enabling policymakers to design responsive TVET curricula (World Bank, 2023).

Challenges of AI Integration in TVET

1. **Limited Digital Infrastructure**

Many TVET institutions in Nigeria lack the necessary infrastructure, including high-speed internet, AI-powered learning platforms, and computing facilities (National Information Technology Development Agency [NITDA], 2023).

2. **High Cost of AI Implementation**

The acquisition and maintenance of AI-driven educational tools require significant investment, which may be unsustainable for underfunded institutions (African Development Bank [AfDB], 2023).

3. **Skills Gap Among Educators**

Many TVET instructors lack AI literacy and digital competencies necessary to effectively implement AI-powered education (Federal Ministry of Education, 2023). Continuous professional development and upskilling programs are essential.

4. **Data Privacy and Ethical Concerns**

AI-driven systems collect and analyze vast amounts of student data, raising concerns about data privacy, cybersecurity, and ethical AI use (International Telecommunication Union [ITU], 2023).

5. **Resistance to Change**

The adoption of AI in TVET may face resistance from educators and stakeholders who are accustomed to traditional teaching methods (UNESCO, 2023). Awareness campaigns and stakeholder engagement are crucial to fostering acceptance.

Way forward (Possible Solution)

To successfully integrate AI into TVET, Nigeria must invest in digital infrastructure, provide AI-focused teacher training programs, and develop policies that encourage ethical AI use. Public-private partnerships (PPPs) can bridge funding gaps, ensuring sustainable AI implementation (WEF, 2023). Furthermore, national strategies should be developed to facilitate digital inclusion, ensuring that AI-driven TVET benefits all regions and socioeconomic groups equally.

AI presents significant opportunities for revolutionizing Nigeria's TVET system. However, overcoming the associated challenges requires collaborative efforts between the government, private sector, and educational institutions. If well implemented, AI can enhance learning outcomes, improve workforce readiness, and contribute to Nigeria's economic diversification efforts in the 21st-century digital landscape.

Government and Private Sector Initiatives

The Nigerian government and private sector have recognized the need for digital skills and AI integration in TVET, leading to various initiatives aimed at enhancing workforce competencies and promoting economic diversification. These initiatives span policy reforms, infrastructure development, partnerships with technology companies, and investment in capacity building.

Government Initiatives

1. **National Digital Economy Policy and Strategy (2020–2030)**

The Nigerian government launched this policy to promote digital literacy and integrate digital skills into all levels of education, including TVET. The policy aims to create a digitally competent workforce, ensuring that graduates are prepared for the demands of the 21st-century labor market (Federal Ministry of Communications and Digital Economy, 2023).

2. **National Skills Qualification Framework (NSQF)**

The NSQF was developed to standardize and recognize skills acquired through TVET programs, ensuring alignment with global best practices. This framework integrates AI-driven skill assessment tools to enhance training quality and employability (Federal Ministry of Education, 2023).

3. **Digital Literacy and Skills Pillar of the National Broadband Plan**

This initiative aims to bridge the digital divide by expanding broadband access to TVET institutions and training centers. Improved internet access facilitates e-learning, AI-driven adaptive training, and digital resource availability (National Information Technology Development Agency [NITDA], 2023).

4. **Nigeria Artificial Intelligence Research Scheme**

This government-driven initiative provides funding for AI-based educational research and innovation in collaboration with universities and TVET institutions. It focuses on developing AI-powered solutions tailored to Nigeria's economic and educational landscape (Central Bank of Nigeria, 2023).

5. **Technical and Vocational Education Expansion Project**

Spearheaded by the Tertiary Education Trust Fund (TETFund), this project supports the establishment of smart TVET centers equipped with AI-driven learning tools, ensuring that vocational training remains relevant in the digital age (TETFund, 2023).

Private Sector Initiatives

1. **Microsoft's Digital Skills for Africa Program**

Microsoft has partnered with the Nigerian government to provide free digital and AI training for TVET students and educators. The program equips learners with in-demand skills such as cloud computing, data analytics, and AI applications (Microsoft Africa, 2023).

2. **Google's AI for Africa Initiative**

Google has introduced AI-driven training programs in Nigerian TVET institutions, offering courses in machine learning, AI ethics, and automation. This initiative aims to enhance digital competencies and prepare students for AI-powered industries (Google AI, 2023).

3. **Cisco Networking Academy**

Cisco has collaborated with Nigerian TVET institutions to offer AI-powered cybersecurity and networking training. These programs help bridge the skills gap in IT and digital infrastructure management (Cisco Africa, 2023).

4. **Huawei ICT Academy**

Huawei has launched digital skills programs in Nigerian polytechnics, training students in AI-powered telecommunications, 5G technology, and cloud computing. This initiative enhances technical capacity and aligns TVET curricula with industry demands (Huawei Technologies, 2023).

5. **Andela's AI and Software Development Bootcamps**

Andela, a tech talent development company, has introduced intensive AI and software development training programs tailored to TVET graduates. These programs connect trainees with global employers, fostering job opportunities beyond Nigeria's borders (Andela, 2023).

The Role of Public-Private Partnerships (PPPs)

Public-private partnerships (PPPs) play a crucial role in strengthening Nigeria's TVET system by leveraging industry expertise, funding, and technology. These collaborations ensure that curricula remain relevant, digital infrastructure is developed, and instructors receive continuous professional development. Joint ventures between government agencies and private tech firms facilitate AI research, digital upskilling, and the adoption of emerging technologies in TVET institutions (World Economic Forum, 2023).

Nigeria's journey towards economic diversification through digital skills and AI integration in TVET depends on sustained investment, policy implementation, and strategic collaborations. By aligning government initiatives with private sector expertise, the country can build a resilient and future-ready workforce, driving sustainable economic growth in the digital era.

Conclusion and Recommendations

Integrating digital skills and AI into Nigeria's TVET system is essential for economic diversification and competitiveness in the global market. By embracing these technologies, Nigeria can develop a skilled workforce capable of driving innovation across various sectors, thereby reducing reliance on traditional industries. Strategic investments in infrastructure, educator training, and supportive policies are crucial to realizing this vision and ensuring that Nigeria's educational system meets the demands of the 21st-century economy.

To fully harness the benefits of digital skills and AI in TVET, the following recommendations are proposed:

1. Government and the private sector should **i**nvest in digital infrastructure to support AI-driven education.
2. Government should continuously train TVET instructors in AI applications and digital tools.
3. TVET institutions should strengthen their partnership with the private sectorespecially tech companies for quality digital and AI driven education.
4. The Federal Government of Nigeria should update national policies to incorporate AI and emerging digital skills.
5. Government should **e**stablish grants and incentives for TVET institutions to integrate AI-driven solutions.

References

African Development Bank. (2023). *Nigeria's youth employment and digital skills initiative: Bridging the gap*. Retrieved from https://www.afdb.org

Andela. (2023). *AI and software development bootcamps for Africa*. Retrieved from https://www.andela.com

Central Bank of Nigeria. (2023). *Nigeria Artificial Intelligence Research Scheme: Supporting innovation in education*. Retrieved from https://www.cbn.gov.ng

Cisco Africa. (2023). *Networking Academy: AI and cybersecurity training in Nigeria*. Retrieved from https://www.cisco.com

Federal Ministry of Communications and Digital Economy. (2023). *National Digital Economy Policy and Strategy (2020-2030)*. Retrieved from https://www.commtech.gov.ng

Federal Ministry of Education. (2023). *National Skills Qualification Framework (NSQF): Enhancing technical education in Nigeria*. Retrieved from https://www.education.gov.ng

Google AI. (2023). *AI for Africa: Building future skills through AI education*. Retrieved from https://ai.google

Huawei Technologies. (2023). *Huawei ICT Academy: Driving AI-powered training in Nigeria*. Retrieved from https://www.huawei.com

International Finance Corporation & World Bank. (2023). *Demand for Digital Skills in Sub-Saharan Africa*. Retrieved from https://documents1.worldbank.org

International Labour Organization. (2023). *TVET and digital skills for sustainable employment in Africa*. Retrieved from https://www.ilo.org

Microsoft Africa. (2023). *Digital skills for Africa: Empowering youth through AI training*. Retrieved from https://www.microsoft.com/africa

National Bureau of Statistics. (2023). *Nigeria's unemployment rate report*. Retrieved from https://www.nigerianstat.gov.ng

National Information Technology Development Agency. (2021). *NITDA Digital State Initiative*. Retrieved from https://en.wikipedia.org/wiki/NITDA_Digital_State_Initiative

National Information Technology Development Agency. (2023). *Digital literacy and skills pillar of the National Broadband Plan*. Retrieved from https://www.nitda.gov.ng

Silas, E. I., Ekong, M. O., & Akpan, I. M. (2024). Exploring AI-Driven Adaptive Learning Systems for Personalized Education in Nigerian TVET Institutions. *World Journal of Innovation and Modern Technology*, 8(5), 188-198.

Tertiary Education Trust Fund (TETFund). (2023). *Technical and Vocational Education Expansion Project: Enhancing smart learning in Nigeria*. Retrieved from https://www.tetfund.gov.ng

Trade.gov. (2023). *Nigeria - Digital Economy*. Retrieved from https://www.trade.gov/country-commercial-guides/nigeria-digital-economy

UNESCO. (2023). *The future of TVET: Global trends in digital skills and AI integration*. Retrieved from https://www.unesco.org

Wikipedia contributors. (2024). *VwakporEfuetanu*. In *Wikipedia, The Free Encyclopedia*. Retrieved from https://en.wikipedia.org/wiki/Vwakpor_Efuetanu

World Economic Forum. (2023). *The global digital skills gap: Bridging the divide through AI and education*. Retrieved from https://www.weforum.org

EMERGING TRENDS IN ROBOTICS AND ARTIFICIAL INTELLIGENCE ON CURRICULUM DEVELOPMENT IN STEM EDUCATION: PREPARING STUDENTS FOR FUTURE SECURITY AND TECHNOLOGICAL INNOVATIONS

Prof. Peter Ashlame Agu and Dr. Iwanger Ruth Samuel
Department of Science, Technology and Mathematics Education, Faculty of Education, Nasarawa State University, Keffi, Nasarawa State

Abstract

The rapid advancement of robotics and artificial intelligence (AI) is transforming industries and reshaping societal structures at an unprecedented pace. As these technologies become increasingly integral to various sectors, including security, healthcare, manufacturing, and transportation, there is a growing imperative to prepare the next generation of professionals who can navigate, innovate, and lead in this evolving landscape. This paper explored the critical intersection of emerging trends in robotics and AI with curriculum development in Science, Technology, Engineering, and Mathematics (STEM) Education. The accelerating pace of advancements in robotics and artificial intelligence (AI) is profoundly influencing numerous sectors, including security, healthcare, manufacturing, and transportation. As these technologies become more pervasive, the demand for a workforce skilled in AI and robotics is surging, underscoring the necessity for an educational paradigm shift, particularly within Science, Technology, Engineering, and Mathematics (STEM) disciplines. A reimagined curriculum should integrate AI-driven problem-solving, robotics engineering, cybersecurity, and ethical considerations, focusing on real-world applications. Innovative educational strategies, such as project-based learning and collaborative problem-solving, are key to fostering critical thinking, creativity, and adaptability. The paper highlighted the challenges of this transition, including the need for teacher training, updated resources, and partnerships between educational institutions, industry, and government. It concludes by proposing a strategic framework for curriculum development that emphasizes not only technical proficiency but also ethical decision-making and responsible innovation, better preparing students to address the complex challenges posed by AI and robotics.

Keywords: Robotics, Artificial Intelligence, STEM Education, Curriculum Development, Technological Innovation, Security Challenges, Ethical Considerations, Project-Based Learning, Interdisciplinary Approaches, Future Workforce.

Introduction

In the 21st century, the rapid advancement of robotics and artificial intelligence (AI) has catalyzed a transformative shift in numerous industries, ranging from manufacturing and healthcare to security and transportation. As these technologies become more embedded in societal infrastructure, the educational system, particularly within Science, Technology, Engineering, and Mathematics (STEM) disciplines, faces the critical challenge of adapting to prepare students for the complexities of a technologically advanced world. The evolution of robotics and artificial intelligence (AI) is a complex journey, spanning decades of technological advancement, scientific discovery, and philosophical exploration. Both fields have grown from speculative ideas into critical components of modern industries and societies. As robotics and AI increasingly intersect, their combined capabilities are reshaping

sectors such as healthcare, manufacturing, security, and even education. Understanding the history and development of these technologies provides valuable insights into their current applications and future potential. The foundations of robotics and AI date back centuries, originating from philosophical ideas about automation and artificial beings. Robotics as a concept can be traced to ancient mythology and engineering, where early civilizations imagined mechanical beings with human-like characteristics. However, practical advancements in robotics didn't begin until the 20th century, with the invention of machines that could automate tasks and mimic basic human actions (Craig, 2005). Similarly, the idea of artificial intelligence has its roots in early philosophical thought, with the question of whether machines could exhibit human-like reasoning and decision-making abilities. In the 1950s, AI became a formal field of study with the pioneering work of researchers like Alan Turing, who proposed the Turing Test as a way to measure machine intelligence. Turing's paper, "Computing Machinery and Intelligence" (1950), laid the groundwork for AI by asking the question, "Can machines think?" (Turing, 1950).

Robotics first gained widespread attention with the rise of industrial automation in the mid-20th century. In 1954, George Devol invented the first programmable robot, Unimate, which was later installed in General Motors' assembly lines in 1961. Unimate revolutionized manufacturing by automating tasks that were repetitive, dangerous, or required precision that humans could not consistently achieve (Devol, 1961). This era marked the birth of industrial robots, which began to play an increasingly important role in manufacturing processes worldwide. The introduction of robotic arms, welding robots, and automated material-handling systems significantly boosted productivity and efficiency. However, these early robots operated in controlled environments, with limited adaptability to dynamic tasks or environments (Craig, 2005).

While robotics advanced through automation, AI evolved along a different path, initially focusing on rule-based systems. Early AI systems relied on symbolic reasoning, where knowledge was represented as rules and logic, allowing machines to perform tasks such as problem-solving and language translation (Russell & Norvig, 2021). These early systems, known as "Good Old-Fashioned AI" (GOFAI), struggled with complex, real-world applications due to the limitations of pre-programmed rules and the inability to learn from data. In the 1980s, AI research shifted towards machine learning, a subfield that allows computers to learn patterns from data without being explicitly programmed. The development of artificial neural networks, inspired by the human brain, marked a significant leap forward. However, the limited computational power of that time restricted the success of early neural networks (Goodfellow, Bengio, & Courville, 2016). The field experienced a resurgence in the 2000s, largely driven by increases in computational power, the availability of big data, and advances in algorithms. This led to the development of deep learning, a branch of machine learning that uses multi-layered neural networks to process complex patterns in data. Breakthroughs in deep learning, particularly in image recognition, natural language processing, and speech recognition, catapulted AI into mainstream applications (LeCun, Bengio, & Hinton, 2015).

As AI developed, it became clear that its integration with robotics would unlock new possibilities. Early robots were programmed to follow predetermined paths and execute specific tasks in structured environments, but they lacked the intelligence to adapt to dynamic, unpredictable situations. By combining AI with robotics, researchers began creating machines

that could perceive their environments, make decisions, and learn from experience (Siciliano & Khatib, 2016). This convergence gave rise to intelligent robots capable of autonomous decision-making, navigation, and interaction. The development of AI-enhanced robots has revolutionized various sectors, such as healthcare, where robotic systems like Da Vinci Surgical Systems assist surgeons in complex procedures with precision and control (Yang, Moore, & Glozman, 2020). In the automotive industry, self-driving cars are a prime example of how robotics and AI are reshaping transportation, with companies like Tesla and Waymo using AI to develop autonomous vehicles that can navigate traffic, detect obstacles, and make real-time decisions (Goodall, 2014).

Robotics and AI in the 21st Century: Current Trends and Innovations

In the 21st century, robotics and AI have become increasingly integrated into both everyday life and critical infrastructure. Some of the key trends and innovations in the evolution of robotics and AI include:

Autonomous Systems

Autonomous robots are becoming more prevalent across industries, from delivery drones and warehouse automation to military applications and space exploration. These systems rely on AI for decision-making, object recognition, and route optimization. For example, Boston Dynamics' robots, such as Spot, have demonstrated the ability to navigate complex terrains, perform repetitive tasks, and even engage in search and rescue missions (Boston Dynamics, 2021).

AI-Driven Healthcare Robotics

The healthcare industry has embraced robotics and AI for diagnosis, treatment, and patient care. AI-driven robots can perform minimally invasive surgeries, assist in rehabilitation, and manage patient records more efficiently. AI systems also assist in medical imaging and drug discovery, where algorithms can analyze vast amounts of data to identify patterns and make predictions faster than humans (Topol, 2019).

Collaborative Robots (Cobots)

Unlike traditional industrial robots, which work in isolation, collaborative robots, or cobots, are designed to work alongside humans. Cobots use AI to understand human actions, adapt to new tasks, and ensure safety in shared workspaces. These robots are increasingly used in manufacturing, assembly lines, and warehouses, enhancing human productivity by automating repetitive or physically demanding tasks (Peshkin & Colgate, 1999).

AI and Robotics in Security and Defense

Robotics and AI have become vital in security and defense, with the development of autonomous drones, unmanned vehicles, and intelligent surveillance systems. These systems can perform tasks such as reconnaissance, threat detection, and precision strikes, raising ethical and security concerns about the role of autonomous weapons in warfare (Scharre, 2018). The future of robotics and AI lies in further advancements in intelligence, autonomy,

and ethical considerations. Researchers are working on developing general AI, where machines would possess human-like cognitive abilities and reasoning. While this remains a distant goal, the implications of such advancements could be transformative for industries, education, and society as a whole (Bostrom, 2014). One of the major challenges in the evolution of robotics and AI is addressing the ethical dilemmas associated with their widespread use. As robots and AI systems make increasingly autonomous decisions, issues such as accountability, bias, privacy, and the displacement of human jobs become central to discussions on responsible AI development (Russell, 2019). The evolution of robotics and AI has been marked by significant milestones, from the early development of rule-based systems and industrial robots to the modern era of autonomous machines and AI-enhanced robots. The convergence of these two fields continues to drive technological innovation across industries, improving efficiency, safety, and decision-making. As robotics and AI continue to advance, they will likely reshape many aspects of human life, presenting both opportunities and challenges that will require careful ethical consideration and regulatory oversight.

Robotics and AI have evolved from theoretical concepts into practical tools that influence daily life and global economies. Robotics, once confined to industrial automation, now plays a crucial role in diverse fields such as medicine, military applications, and autonomous vehicles. AI, on the other hand, has transitioned from basic machine learning algorithms to sophisticated systems capable of performing complex tasks like natural language processing, image recognition, and predictive analytics (Russell & Norvig, 2021). These advancements have significant implications for the workforce, requiring professionals who not only understand these technologies but can also innovate within and beyond their existing frameworks. As AI and robotics continue to integrate into critical infrastructure and systems, they bring forth new security concerns, particularly regarding cybersecurity and ethical considerations in autonomous systems (Bostrom & Yudkowsky, 2014). These emerging trends necessitate a reevaluation of how STEM education is structured and delivered.

The Need for Curriculum Transformation in STEM Education in Nigeria

Traditional STEM curricula have long focused on foundational principles across science and mathematics, often taught in silos with minimal interdisciplinary engagement. While these foundations remain crucial, the rapid evolution of technology requires a curriculum that not only imparts technical knowledge but also fosters critical thinking, creativity, and an understanding of the broader societal implications of technological advances (National Research Council, 2012). To address these needs, STEM education must undergo a significant transformation. This includes integrating robotics and AI into the curriculum in ways that are both practical and forward-thinking. Students should be exposed to hands-on learning experiences, such as building and programming robots, developing AI models, and solving real-world problems using these technologies (Papert, 1980). Additionally, the curriculum must incorporate discussions on the ethical and security challenges posed by AI and robotics, preparing students to make informed decisions in their future careers.

In the rapidly evolving global economy, science, technology, engineering, and mathematics (STEM) education has emerged as a critical driver of innovation and economic development. Countries with strong STEM education systems are better positioned to produce skilled professionals capable of addressing complex challenges in fields such as healthcare, technology, manufacturing, and environmental sustainability. Nigeria, Africa's most populous

country, faces significant challenges and opportunities in this regard. Despite its vast natural and human resources, the nation's STEM education system has lagged behind in preparing students for the demands of the 21st century, particularly in light of emerging trends in artificial intelligence (AI), robotics, cybersecurity, and other technological innovations. This paper explores the need for curriculum transformation in STEM education in Nigeria. The discussion highlights the inadequacies of the current STEM curriculum, examines the socio-economic and technological factors driving the need for reform, and proposes strategies for creating a modernized curriculum that can better equip Nigerian students with the skills necessary for global competitiveness and national development.

Current State of STEM Education in Nigeria

STEM education in Nigeria, like in many developing countries, faces multiple challenges. These include outdated curricula, insufficient resources, inadequate teacher training, and a lack of infrastructure. According to the National Policy on Education (Federal Ministry of Education, 2013), Nigeria's educational system is designed to promote technological and scientific development. However, in practice, the STEM curriculum remains largely theoretical, with little emphasis on practical, hands-on learning or interdisciplinary approaches.

i. Outdated Curriculum

One of the primary issues in Nigeria's STEM education is the outdated curriculum. The curriculum in many secondary schools and tertiary institutions focuses heavily on rote learning and memorization, often neglecting the practical applications of STEM principles in real-world scenarios (Adeyemi, 2018). For instance, the curriculum for science subjects like biology, chemistry, and physics often lags behind current global trends in these fields. Topics such as artificial intelligence, machine learning, biotechnology, and robotics are either completely absent or taught in a superficial manner, limiting students' exposure to the latest technological advancements (Anaduaka & Okafor, 2013).

ii. Lack of Practical Skills

STEM education in Nigeria also suffers from a lack of practical, hands-on learning experiences. Many schools lack the necessary equipment, laboratories, and resources to teach STEM subjects effectively. According to Ojo and Adu (2018), most Nigerian schools operate with poorly equipped science laboratories, making it difficult for students to engage in experiments or understand the practical applications of STEM concepts. This lack of practical skills is a major disadvantage in a global economy that increasingly values innovation, creativity, and problem-solving abilities over rote memorization.

iii. Teacher Training and Professional Development

Another critical challenge is the inadequate training of teachers in STEM subjects. Many educators in Nigeria lack the necessary skills to teach modern STEM curricula effectively, particularly in the areas of technology and engineering. Teachers are often not familiar with the latest developments in AI, robotics, or digital literacy, which hinders their ability to prepare students for the modern workforce (Ogunniyi & Fakorede, 2019). Furthermore, there

is a lack of continuous professional development programs for teachers, which could help them keep up with new teaching methods and technologies.

Drivers for Curriculum Transformation in STEM Education

Several socio-economic, technological, and policy-related factors underscore the urgent need for transforming Nigeria's STEM education curriculum. These drivers include global technological advancements, the need for economic diversification, labor market demands, and Nigeria's ambition to be a leader in Africa's technological future.

Global Technological Advancements

The rapid pace of technological advancement globally has highlighted the inadequacies of Nigeria's STEM curriculum. Innovations in AI, machine learning, renewable energy, biotechnology, and other fields require a workforce with a strong foundation in STEM subjects. According to the World Economic Forum (2020), more than half of the jobs of the future will require STEM-related skills. However, Nigerian students are not currently being equipped with the knowledge and skills to compete in this global economy, where STEM fields are driving innovation. Countries that have embraced technological innovation have reaped significant economic benefits, and Nigeria risks being left behind if it does not adapt. A modernized STEM curriculum that incorporates AI, robotics, data science, and other emerging technologies is crucial to ensuring that Nigerian students are prepared for the challenges and opportunities of the future (Bashir, 2017).

Economic Diversification and National Development

Nigeria's heavy reliance on oil exports for its economic growth has long been a point of vulnerability. The fluctuating price of oil and the environmental impacts of fossil fuel dependency underscore the need for economic diversification. Developing a strong STEM workforce can play a key role in this diversification effort, driving growth in industries such as agriculture, manufacturing, renewable energy, and information technology (IT) (Omoju & Abraham, 2014). For instance, renewable energy technologies, such as solar power, represent a significant opportunity for Nigeria to address its energy challenges while reducing environmental impact. To capitalize on this potential, a reformed STEM curriculum must include energy studies, environmental science, and engineering, preparing students to innovate in these fields.

Labor Market Demands and Employment Opportunities

The labor market in Nigeria is increasingly demanding professionals with advanced STEM skills. However, many graduates lack the requisite technical competencies to fill these roles, leading to a mismatch between the skills taught in schools and the needs of the workforce (Ogunniyi & Fakorede, 2019). Employers in sectors such as IT, telecommunications, healthcare, and engineering are looking for employees with skills in data analysis, software development, and other technical areas. Curriculum reform is necessary to bridge this skills gap and make Nigerian graduates more competitive on the global stage.

Strategies for Curriculum Transformation

Given the challenges outlined above, transforming the STEM curriculum in Nigeria will require a comprehensive approach that includes policy changes, investment in infrastructure, teacher training, and public-private partnerships.

i. Incorporating Emerging Technologies

The STEM curriculum in Nigeria needs to be updated to include emerging technologies such as AI, robotics, and biotechnology. This will require revising the syllabus to ensure that students are exposed to these fields early on and throughout their education. Schools should introduce courses in coding, programming, and data science, starting from the secondary level, to equip students with the skills necessary for the modern economy (Oladipo & Salami, 2016).

ii. Promoting Hands-on Learning and Innovation

To foster critical thinking and innovation, the curriculum should emphasize project-based learning, where students can apply theoretical knowledge to real-world problems. Schools should be equipped with modern laboratories and resources that allow students to engage in hands-on learning, from building simple robots to experimenting with renewable energy technologies. Innovation hubs and STEM-focused extracurricular activities, such as robotics clubs and science fairs, can also encourage creativity and collaboration (Aina, 2013).

iii. Teacher Training and Professional Development

Teacher training is critical to the success of any curriculum transformation. The Nigerian government must invest in continuous professional development programs for STEM teachers, ensuring they are equipped with the knowledge and tools to teach modern STEM curricula. This includes training in digital literacy, new teaching methodologies, and the use of educational technologies (Adeyemo, 2010). Partnerships with international organizations and universities can help provide access to global best practices in STEM education.

iv. Public-Private Partnerships

The transformation of Nigeria’s STEM education system cannot be achieved by the government alone. Public-private partnerships can play a key role in providing resources, funding, and expertise. Companies in the technology, engineering, and energy sectors can partner with educational institutions to offer internships, mentorship programs, and sponsorship of STEM projects. Such collaborations can bridge the gap between classroom learning and industry needs, ensuring that students acquire relevant skills (Ogunmade, 2005).

The need for curriculum transformation in STEM education in Nigeria is both urgent and vital to the country's future. As technological advancements continue to reshape industries and economies worldwide, Nigeria must invest in modernizing its STEM curriculum to prepare students for the challenges and opportunities of the 21st century. This transformation will require significant changes in policy, teacher training, infrastructure, and curriculum content. By incorporating emerging technologies, promoting hands-on learning, and fostering public-

private partnerships, Nigeria can build a STEM education system that equips its students to compete on a global scale, driving innovation and national development.

Key Areas for STEM Curriculum Enhancement to Incorporate AI and Robotics

The rapid advancements in artificial intelligence (AI) and robotics are reshaping industries and transforming the global economy. As a result, there is an urgent need to enhance STEM (science, technology, engineering, and mathematics) curricula to prepare students for the challenges and opportunities presented by these emerging fields. By integrating AI and robotics into STEM education, students will gain critical skills that will enable them to thrive in a future where intelligent machines and automation play a central role in everyday life. The key areas of STEM curriculum enhancement necessary to incorporate AI and robotics effectively, ensuring that students are well-equipped to navigate the future technological landscape are as follows:

Foundational Knowledge in AI and Robotics

A critical first step in integrating AI and robotics into STEM education is building a solid foundation of knowledge in these subjects. This foundational knowledge should include the basic principles of AI, machine learning, and robotics, enabling students to understand both the theoretical and practical aspects of these technologies.

i. AI Fundamentals

To incorporate AI into the curriculum, students must first understand core concepts such as algorithms, data structures, neural networks, and machine learning. Students should also learn about the history of AI and the impact it has had on various industries. The curriculum should introduce topics such as supervised and unsupervised learning, natural language processing (NLP), and computer vision, which are central to modern AI systems (Russell & Norvig, 2020).

ii. Robotics Basics

Similarly, students need to be introduced to the fundamentals of robotics, including key concepts such as kinematics, dynamics, control systems, and sensor integration. Robotics education should focus on both hardware and software, allowing students to explore the design and programming of robots. This includes teaching students about the use of sensors, actuators, and embedded systems in robots, as well as the importance of robotics in manufacturing, healthcare, and autonomous vehicles (Spong *et al.,* 2005).

Hands-on Learning and Project-Based Education

One of the most effective ways to teach AI and robotics is through hands-on, project-based learning (PBL). This approach engages students in real-world problem-solving and allows them to apply theoretical knowledge to practical challenges.

i. AI-Driven Projects

STEM curricula should include projects that require students to design, develop, and implement AI systems. For instance, students can work on building simple AI models using programming languages like Python, and frameworks like TensorFlow or PyTorch. These projects could involve creating AI models for image recognition, speech processing, or data classification (Goodfellow *et al.*, 2016). This kind of hands-on experience not only deepens students' understanding of AI concepts but also encourages creativity and innovation.

ii. Robotics Prototyping

For robotics, project-based learning could involve designing and building robots that perform specific tasks, such as navigating mazes, lifting objects, or interacting with their environment. Schools can incorporate robotics kits (e.g., LEGO Mindstorms or VEX Robotics) that allow students to experiment with sensors, motors, and microcontrollers to build functioning robots. This approach fosters problem-solving, critical thinking, and teamwork skills while providing students with practical exposure to engineering concepts (Jones *et al.*, 2000).

Integration of Programming and Coding Skills

To work with AI and robotics, students need to develop strong programming and coding skills. Incorporating coding into the STEM curriculum is essential, as it provides students with the tools to create algorithms, develop software, and control robots.

i. Coding for AI

In the context of AI, students should learn programming languages commonly used in AI development, such as Python, R, and Java. Python, in particular, is widely used for AI and machine learning due to its simplicity and the availability of powerful libraries like Scikit-learn, Keras, and OpenAI's Gym. Students can be introduced to coding through interactive platforms like Code.org or MIT's Scratch before progressing to more advanced programming languages and AI-specific libraries (Alzahrani *et al.*, 2019).

ii. Robotics Programming

For robotics, students should learn programming languages such as C++, Python, or Java, which are commonly used in robotic systems. Additionally, teaching students how to work with robot operating systems (ROS) is valuable, as ROS provides a framework for developing robotics software. ROS allows students to create simulations and test robotic systems without needing physical hardware, making it a versatile tool for STEM education (Quigley *et al.*, 2009).

Interdisciplinary Learning and Collaboration

AI and robotics are inherently interdisciplinary fields that draw from various areas of STEM, including mathematics, computer science, engineering, and physics. Enhancing the STEM curriculum to integrate AI and robotics should, therefore, emphasize the interconnectedness of these disciplines.

i. Mathematics and AI

Mathematics is foundational to AI and machine learning. Concepts such as calculus, linear algebra, probability, and statistics are essential for understanding algorithms, training machine learning models, and analyzing data (Goodfellow *et al.,* 2016). The STEM curriculum should ensure that students are proficient in these mathematical areas and understand how they relate to AI.

ii. Physics and Robotics

Robotics, on the other hand, relies heavily on principles from physics, particularly in areas such as mechanics, electromagnetism, and control theory. Enhancing the curriculum to include robotics should involve linking these physical principles to robotic motion, sensor integration, and energy management (Spong *et al.,* 2005). Collaborative projects that combine knowledge from physics and engineering help students see how interdisciplinary learning enhances problem-solving in real-world applications.

Ethics and Responsible AI/Robotics

As AI and robotics technologies become more widespread, it is increasingly important to teach students about the ethical implications of these technologies. Understanding the social, legal, and moral consequences of AI and robotics is critical to ensuring that these technologies are used responsibly.

i. AI Ethics

Students should learn about the ethical challenges associated with AI, such as bias in algorithms, data privacy, and the impact of automation on jobs. The curriculum should cover discussions on how AI can be designed to promote fairness, transparency, and accountability. Topics such as the ethical use of facial recognition technologies, the risks of autonomous weapons, and the potential for AI to exacerbate social inequalities are important areas for exploration (Müller, 2020).

ii. Robotics and Society

Similarly, the curriculum should address the ethical considerations of robotics, such as the societal impacts of robotic automation and the ethical treatment of robots in contexts like healthcare and caregiving. For instance, students can engage in debates about the role of autonomous robots in warfare or the use of robots to replace human workers in industries like manufacturing and agriculture (Bryson, 2010).

Collaboration with Industry and Research Institutions

To ensure that STEM curricula stay relevant and reflect the latest developments in AI and robotics, there should be stronger partnerships between educational institutions, industry, and research organizations. Collaboration with these stakeholders can help bridge the gap between theoretical learning and practical application.

i. Industry Partnerships

Schools can collaborate with tech companies that specialize in AI and robotics to provide students with access to cutting-edge technology, internships, and mentorship opportunities. These partnerships can also lead to the creation of real-world projects, competitions, and hackathons that allow students to solve industry-specific challenges (Freeman *et al.*, 2014). For example, tech companies like Google, Microsoft, and IBM offer AI and robotics programs designed to help students gain practical experience.

ii. Research Integration

Collaboration with research institutions and universities is also crucial for integrating AI and robotics research into the STEM curriculum. By exposing students to ongoing research and development in these fields, they gain insight into the latest trends, breakthroughs, and applications. Research institutions can also offer workshops, seminars, and collaborative projects that give students hands-on experience in cutting-edge AI and robotics research (Dym *et al.,* 2005).

Teacher Training and Professional Development

Incorporating AI and robotics into the STEM curriculum requires teachers to have a deep understanding of these technologies. Therefore, professional development and training programs for teachers are essential.

i. Teacher Training Programs

Teacher training programs should focus on providing educators with the knowledge and tools they need to effectively teach AI and robotics concepts. These programs should cover both the technical aspects of AI and robotics as well as effective teaching strategies for delivering these concepts to students. Additionally, teachers should be trained in how to use educational platforms and tools designed for teaching AI and robotics, such as AI4K12 or Raspberry Pi kits (Touretzky *et al.,* 2019).

ii. Continuous Professional Development

Continuous professional development programs should be offered to keep teachers up to date with the latest advancements in AI and robotics. These programs can include workshops, online courses, and certifications that help educators stay current with the fast-evolving technologies in these fields (Freeman *et al.,* 2014).

Enhancing STEM curricula to incorporate AI and robotics is essential to preparing students for the future workforce and technological innovations. Key areas of focus include building foundational knowledge, fostering hands-on learning, integrating coding skills, promoting interdisciplinary collaboration, addressing ethical considerations, collaborating with industry, and investing in teacher training. By emphasizing these areas, educational institutions can ensure that students are equipped with the necessary skills to succeed in an increasingly AI-driven and automated world.

Challenges in Integrating AI and Robotics into STEM Curriculum Development

Incorporating artificial intelligence (AI) and robotics into STEM (science, technology, engineering, and mathematics) curricula is essential for preparing students for the future workforce. However, integrating these emerging technologies into education poses several challenges due to the complexity of AI and robotics and the need for comprehensive educational reform. Below, we explore key challenges that schools, educators, and policymakers face in developing and implementing curricula that effectively integrate AI and robotics.

i. Lack of Teacher Expertise and Training

One of the most significant challenges in integrating AI and robotics into STEM education is the shortage of teachers with sufficient expertise in these fields. Many educators lack the technical knowledge and experience required to teach advanced topics such as machine learning, neural networks, robotics programming, and sensor technology.

ii. Insufficient Professional Development Programs

Many schools do not provide adequate professional development opportunities for teachers to learn about AI and robotics. Training programs often focus on more traditional STEM subjects and fail to incorporate emerging technologies. This leaves teachers unprepared to deliver content that covers the latest advancements in AI and robotics. Furthermore, the rapid pace of technological change means that even teachers with some background in AI and robotics may struggle to stay current without continuous learning opportunities (Touretzky *et al.*, 2019).

iii. Teacher Resistance and Confidence

In addition to a lack of knowledge, some teachers may feel intimidated by the prospect of teaching AI and robotics due to the perceived difficulty of the subject matter. This can lead to resistance to curriculum changes or a lack of confidence in delivering lessons. Teachers who are unfamiliar with AI and robotics may hesitate to experiment with new technologies in the classroom, which hampers the adoption of innovative teaching methods (Buckner & Boyd, 2015).

Cost of Resources and Infrastructure

Integrating AI and robotics into STEM curricula requires significant financial investment in terms of hardware, software, and infrastructure. This challenge is particularly pronounced in underfunded schools and regions with limited access to technological resources.

i. Cost of Equipment

Robotics kits, AI development platforms, sensors, and other specialized tools needed for teaching AI and robotics are often expensive. Schools need to invest in hardware such as robots, microcontrollers, 3D printers, and computers capable of running machine learning algorithms. Additionally, some robotics and AI software packages require licensing fees,

further increasing the cost burden on schools. These financial barriers can prevent institutions from providing students with hands-on experience in AI and robotics (Valencia *et al.,* 2016).

ii. Inequity in Access

The disparity in funding between well-resourced and under-resourced schools leads to inequities in access to AI and robotics education. Wealthier schools are more likely to have the resources to invest in cutting-edge technology, while schools in low-income areas may struggle to provide basic STEM equipment. This digital divide risks creating a situation where only privileged students have access to the skills needed for the future job market, exacerbating existing inequalities (Anderson & Perrin, 2018).

Curriculum Overload and Rigid Educational Systems

Incorporating AI and robotics into the existing STEM curriculum can be challenging due to an already crowded schedule. Educators often face pressure to cover a wide range of subjects within limited classroom time, leaving little room for new topics.

i. Curriculum Overload

STEM curricula are already packed with essential content that teachers must cover within a school year, including foundational topics in mathematics, science, and engineering. Adding AI and robotics to the curriculum without sacrificing existing content creates a challenge for educators, who may feel overwhelmed by the volume of material they need to teach. This leads to concerns about diluting the quality of education or rushing through key concepts to fit everything into the curriculum (Blikstein, 2018).

ii. Rigid Educational Systems

Many educational systems are resistant to change due to the bureaucratic processes involved in curriculum reform. The introduction of new subjects such as AI and robotics often requires approval from education boards, policymakers, and other governing bodies, which can be time-consuming and difficult to achieve. Traditional assessment methods, such as standardized testing, may not be well-suited to evaluating students' skills in AI and robotics, further complicating efforts to integrate these subjects into existing frameworks (Zhao & Watterston, 2021).

Rapidly Evolving Technology

AI and robotics are fields that evolve at an extremely fast pace, with new developments and breakthroughs occurring regularly. This presents a challenge for curriculum developers, who must ensure that educational content remains up-to-date and relevant in light of these constant advancements.

i. Keeping Curriculum Relevant

AI and robotics technologies are advancing at a rate that often outpaces the development of educational materials. By the time a curriculum is fully implemented, the technologies it

covers may already be outdated. This poses a challenge for educators, as they must continuously revise and update the curriculum to reflect the latest innovations, which requires time, effort, and expertise (Luckin *et al.*, 2016).

ii. Uncertainty in Future Job Markets

The fast-changing nature of AI and robotics also makes it difficult to predict the skills that students will need in the future workforce. As automation and intelligent systems evolve, new job roles will emerge, and others will become obsolete. This uncertainty complicates curriculum planning, as educators must strike a balance between teaching foundational principles and preparing students for technologies that have not yet been fully realized (Brynjolfsson & McAfee, 2014).

Lack of Standardized Curriculum Guidelines

AI and robotics are relatively new areas of study in the K-12 and higher education systems, and there is currently a lack of standardized guidelines for incorporating these subjects into the curriculum.

i. Inconsistent Curriculum Models

Different schools and districts may adopt varying approaches to teaching AI and robotics, leading to inconsistencies in what students are learning. Without clear, standardized curriculum guidelines, schools are left to design their own AI and robotics programs, resulting in disparities in the depth and quality of education. This lack of standardization also makes it difficult to assess students' proficiency and progress in these fields (Touretzky *et al.*, 2019).

ii. Absence of AI/Robotics Frameworks

While there are well-established frameworks for teaching subjects such as mathematics and science (e.g., the Next Generation Science Standards), similar frameworks for AI and robotics are still in development. Organizations like AI4K12 are working on defining what students should know about AI at different grade levels, but these efforts are still in their early stages. Until robust frameworks are widely adopted, schools may struggle to design comprehensive AI and robotics curricula (Touretzky *et al.*, 2019).

Ethical Concerns and Societal Implications

AI and robotics raise important ethical questions, such as how intelligent systems should be used, who should have control over these technologies, and what societal impacts they may have. These issues are particularly relevant in the context of education, where students need to learn not only the technical aspects of AI and robotics but also their broader implications.

i. Teaching Responsible AI and Robotics

Educators face the challenge of incorporating ethical considerations into AI and robotics education. Students must be taught about the potential biases in AI systems, the privacy concerns surrounding data collection, and the impact of automation on employment.

However, integrating these complex and nuanced topics into the curriculum can be difficult, particularly when teachers themselves may lack training in AI ethics (Müller, 2020).

ii. Addressing Public Perceptions

The public perception of AI and robotics often includes concerns about job displacement, surveillance, and the rise of autonomous systems. These concerns can lead to resistance from parents, policymakers, or community members who may view AI and robotics education with skepticism. Overcoming these societal barriers requires a concerted effort to educate the public about the benefits and risks of AI and robotics, as well as the importance of preparing students for the future (Bryson, 2010).

Integrating AI and robotics into STEM curricula presents numerous challenges, ranging from a lack of teacher expertise to the high cost of resources and infrastructure, as well as the difficulty of keeping curricula up-to-date with rapidly evolving technologies. Addressing these challenges will require coordinated efforts from educators, policymakers, industry partners, and research institutions. By investing in teacher training, developing standardized curriculum guidelines, and fostering collaboration with the tech industry, schools can create a learning environment that prepares students for the future workforce and the ethical implications of AI and robotics.

Strategic Framework for STEM Curriculum Development to Effectively Prepare Students for Future Technological Innovations and Security Challenges

As the world rapidly moves towards technological advancement driven by artificial intelligence (AI), robotics, cybersecurity, and other emerging innovations, there is an urgent need for a strategic framework that aligns STEM (science, technology, engineering, and mathematics) education with these developments. STEM curriculum development should focus not only on imparting foundational knowledge but also on equipping students with the skills, competencies, and ethical understanding necessary to thrive in a technology-driven world. Below is a strategic framework for STEM curriculum development aimed at preparing students for future technological innovations and security challenges.

1. Vision and Goals for STEM Curriculum

The first step in designing a strategic STEM curriculum is to establish clear goals and a vision that aligns with the needs of the future workforce. The curriculum should aim to:

i. Equip students with future-ready skills: Focus on teaching critical thinking, problem-solving, adaptability, and creativity, which are essential for thriving in a world shaped by AI, robotics, and automation.
ii. Integrate emerging technologies: Incorporate AI, robotics, machine learning, data science, cybersecurity, and other key technologies into the curriculum.
iii. Address security challenges: Teach students about cybersecurity risks, data privacy, and the ethical use of technology.
iv. Promote ethical and responsible technology use: Foster a culture of responsible innovation by teaching students about the ethical implications of AI, robotics, and other advanced technologies.

2. Competency-Based Learning and Skills Development

A competency-based approach ensures that students not only acquire knowledge but also develop practical, transferable skills needed for the technological landscape. Competency-based learning emphasizes skills mastery, adaptability, and continuous learning.

A. Core Competencies in AI, Robotics, and Cybersecurity

The curriculum should focus on developing competencies in:

i. Artificial Intelligence (AI)**:** Understanding algorithms, machine learning models, and their applications.
ii. Robotics: Hands-on experience with building and programming robots, understanding kinematics, control systems, and robotic sensors.
iii. Cybersecurity: Awareness of data protection, encryption, threat detection, and safe practices in the digital world.

B. Digital Literacy and Programming Skills

Incorporating coding and digital literacy into all grade levels is essential for students to develop the programming and computational thinking skills necessary for working with AI and robotics technologies. Programming languages like Python, C++, and Java should be taught, as well as frameworks used in AI development (e.g., TensorFlow) and robotics (e.g., Robot Operating System [ROS]).

3. Hands-On, Project-Based Learning (PBL)

Hands-on, project-based learning (PBL) is a powerful pedagogical approach for fostering deep understanding and innovation. Through PBL, students work on real-world challenges, applying theoretical knowledge to practical problems.

A. AI and Robotics Projects

Encourage students to work on interdisciplinary projects that integrate AI, robotics, and data analysis. For example:

i. AI projects: Develop AI models for image recognition, language translation, or predictive analytics.
ii. Robotics projects: Design and build robots that perform specific tasks, such as navigation, object manipulation, or interaction with humans.

B. Cybersecurity Simulations

Incorporate cybersecurity simulations that allow students to experience and respond to cyberattacks, ensuring they understand how to protect systems from vulnerabilities. These simulations can teach students critical skills in network security, encryption, and ethical hacking.

4. Interdisciplinary and Collaborative Learning

AI and robotics are inherently interdisciplinary, requiring knowledge from multiple fields such as mathematics, computer science, physics, and engineering. STEM curricula should encourage interdisciplinary collaboration and teamwork.

A. Cross-Disciplinary Integration

STEM subjects should not be taught in isolation but should instead reflect the interconnectedness of these fields. For instance:

i. Mathematics: Use mathematics to teach data analysis, algorithms, and optimization techniques used in AI.
ii. Physics: Apply principles of physics, such as mechanics and electromagnetism, to understand robotic motion and control systems.
iii. Engineering: Teach engineering design processes alongside robotics projects to instill problem-solving and innovation skills.

B. Collaboration and Teamwork

Encourage collaboration by incorporating group projects that require students to work in teams to solve complex problems. This mirrors real-world tech environments, where collaboration across disciplines is essential for innovation.

5. Focus on Ethical, Social, and Security Implications of Technology

As students become more proficient in AI, robotics, and cybersecurity, it is critical to also address the ethical, social, and security implications of these technologies.

A. Ethics in AI and Robotics

Courses should include discussions about:

i. Bias in AI algorithms: How biased datasets can lead to unfair outcomes in AI systems.
ii. Job displacement: The impact of robotics and AI on employment and the future of work.
iii. Autonomous systems: The ethical considerations of autonomous weapons, self-driving cars, and healthcare robots.

B. Cybersecurity and Privacy

Cybersecurity education should focus on the importance of protecting data and maintaining privacy in a digital world. Students should learn how to create secure systems, understand the implications of data breaches, and recognize ethical hacking as a legitimate skill.

6. Teacher Training and Professional Development

For AI, robotics, and cybersecurity to be effectively integrated into STEM curricula, teachers

must be equipped with the knowledge and skills to teach these subjects. Teacher training and continuous professional development are crucial to this effort.

A. Comprehensive Teacher Training

Teachers need training programs that focus on:

i. AI and robotics education: Equipping teachers with the knowledge to teach both theoretical and practical aspects of AI and robotics.
ii. Cybersecurity fundamentals: Helping educators understand the principles of data protection and cybersecurity risks.
iii. Project-based learning (PBL) methods: Training teachers to design and implement PBL lessons in AI, robotics, and cybersecurity.

B. Continuous Learning and Support

Provide ongoing professional development opportunities for teachers to stay current with the latest trends in AI, robotics, and cybersecurity. This can be done through workshops, webinars, online courses, and collaborations with industry professionals.

7. Partnerships with Industry and Research Institutions

To ensure that the STEM curriculum is aligned with the needs of the future workforce, schools and universities should collaborate with industry and research institutions.

i. Industry Collaboration

Partnering with tech companies can provide students with access to cutting-edge tools, internships, mentorship opportunities, and real-world projects. These partnerships can also help schools stay updated on the latest technological trends and industry demands.

ii. Research and Innovation Labs

Establish research labs and innovation centers in schools where students can work on AI, robotics, and cybersecurity projects under the guidance of industry experts and researchers. These labs can serve as hubs for experimentation and innovation, allowing students to explore new technologies in a hands-on environment.

8. Continuous Curriculum Evaluation and Adaptation

Given the rapidly evolving nature of AI, robotics, and cybersecurity, it is essential to continuously evaluate and update the STEM curriculum to ensure it remains relevant.

i. Regular Curriculum Reviews

Implement a system for regularly reviewing the STEM curriculum to ensure that it aligns with the latest technological advancements and industry needs. This could involve feedback from teachers, students, industry partners, and education experts.

ii. Flexibility and Adaptability

The curriculum should be designed to be flexible and adaptable, allowing for the integration of new technologies and teaching methods as they emerge. This flexibility is crucial for keeping students engaged with the latest innovations and ensuring that their education remains forward-looking.

To prepare students for future technological innovations and security challenges, STEM curriculum development must adopt a forward-thinking, flexible, and interdisciplinary approach. This strategic framework emphasizes the importance of foundational knowledge, hands-on learning, ethical considerations, and collaboration with industry to equip students with the skills they need to thrive in a rapidly changing world. By addressing these key areas, educational institutions can create a robust STEM curriculum that ensures students are ready for the future of work and the ethical and security challenges posed by emerging technologies.

Conclusion

As robotics and AI continue to advance, their influence on society and industry will only grow. Preparing students to thrive in this rapidly changing environment requires a STEM curriculum that is both comprehensive and adaptable. By integrating AI and robotics into the curriculum, emphasizing interdisciplinary approaches, and addressing ethical and security considerations, educational institutions can equip students with the skills they need to succeed in the future. This paper has outlined a strategic framework for curriculum development that aligns with the demands of future technological innovations and security challenges, offering a pathway for STEM education to remain relevant and effective in the 21st century.

References

Adeyemi, T. O. (2018). Science Education in Nigeria: The Challenges and Future Directions. *International Journal of Educational Administration and Policy Studies*, 10(3), 29-34.

Adeyemo, S. A. (2010). The need for integration of information technology (IT) into the scienceand technology curriculum of Nigerian universities. *Educational Research and Reviews*, 5(5), 235-239.

Aina, J. K. (2013). Effective Teaching and Learning in Science Education through Information and Communication Technology. *Journal of Research & Method in Education*, 2(5), 43-47.

Alzahrani, A., et al. (2019). Artificial intelligence in education: A review of learning environmentsthat utilize AI to improve student learning outcomes. *Journal of Educational Technology*, 48(2), 231-245.

Anaduaka, U. S., & Okafor, I. (2013). The Universal Basic Education (UBE) Programme in Nigeria: Problems and Prospects. *Basic Research Journal of Education Research and Review*, 2(3), 42-48.

Anderson, M., & Perrin, A. (2018). *Tech Adoption Climbs Among Older Adults*. Pew Research Center.

Bashir, I. (2017). Repositioning Science, Technology, Engineering and Mathematics (STEM) Education for National Development in Nigeria. *International Journal of Advanced Research*, 5(3), 1076-1082.

Blikstein, P. (2018). Pre-college robotics: Research and evaluation. In *Robotics in K-12*

Education: A New Technology for Learning (pp. 14-35). IGI Global.

Boston Dynamics. (2021). Spot: Agile Mobile Robot. Boston Dynamics. Retrieved from https://www.bostondynamics.com/spot

Bostrom, N. (2014). Superintelligence: Paths, Dangers, Strategies. Oxford University Press.

Bostrom, N., & Yudkowsky, E. (2014). *The Ethics of Artificial Intelligence*. In K. Frankish & W. M. Ramsey (Eds.), The Cambridge Handbook of Artificial Intelligence (pp. 316-334). Cambridge University Press.

Brynjolfsson, E., & McAfee, A. (2014). *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*. W. W. Norton & Company.

Bryson, J. (2010). Robots should be slaves. In *Close engagements with artificial companions* (63-74). John Benjamins.

Buckner, E., & Boyd, M. (2015). Teachers' technology adoption in teaching and learning: Modelling the decision-making process. *Education and Information Technologies*, 20(3), 245-264.

Carnegie Mellon Robotics Academy. (2023). Educational Robotics Resources. Carnegie Mellon University. Retrieved from https://www.cmu.edu/roboticsacademy/

Craig, J. J. (2005). Introduction to Robotics: Mechanics and Control (3rd ed.). Pearson Prentice Hall.

Devol, G. (1961). Programmable Article Transfer. US Patent 2,988,237.

Domingos, P. (2015). The Master Algorithm: How the Quest for the Ultimate Learning Machine Will Remake Our World. Basic Books.

Dym, C. L., et al. (2005). Engineering design thinking, teaching, and learning. *Journal of Engineering Education*, 94(1), 103-120.

Federal Ministry of Education. (2014). *National Policy on Education*. Abuja: NERDC Press.

Freeman, A., et al. (2014). Challenges and opportunities for robotics in the STEM curriculum. *Robotics in Education*, 14, 57-66.

Goodall, N. J. (2014). *Machine Ethics and Automated Vehicles*. In Road Vehicle Automation (93-102). Springer.

Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep learning*. MIT Press.

Gura, M. (2018). The EdTech Advocate's Guide to Leading Change in Schools: A ComprehensiveFramework for Improving Achievement Through Technology. International Society for Technology in Education.

Jones, F., et al. (2000). Hands-on robotics projects in K-12 classrooms. *Journal of Science Education and Technology*, 9(3), 245-251.

LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep Learning. Nature, 521(7553), 436-444.

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence Unleashed: An Argument for AI in Education*. Pearson.

Means, B. (2010). Technology and Education Change: Focus on Student Learning. *Journal of Research on Technology in Education*, 42(3), 285-307.

MIT. (2023). MIT Artificial Intelligence and Robotics Courses. Massachusetts Institute of Technology. Retrieved from https://www.mit.edu/

Moor, J. H. (2006). The Nature, Importance, and Difficulty of Machine Ethics. IEEE Intelligent Systems, 21(4), 18-21.

Müller, V. C. (2020). Ethics of artificial intelligence and robotics. In *The Stanford Encyclopedia of Philosophy*.

National Research Council. (2012). A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. The National Academies Press.

Ogunmade, T. O. (2005). *The Status and Quality of Secondary Science Teaching and Learning*

in Lagos State, Nigeria. *Unpublished Doctoral Dissertation, Edith Cowan University*.

Ogunniyi, A., & Fakorede, S. (2019). Teaching STEM in Nigerian Schools: Challenges and Prospects. *Journal of Education and Practice*, 10(12), 10-18.

Ojo, O. E., & Adu, E. O. (2018). Science Education in Nigeria: The Role of Government in Enhancing Sustainability. *Journal of Education and Learning*, 12(1), 12-24.

Oladipo, S. E., & Salami, O. E. (2016). Challenges of STEM Education in Nigeria and the WayForward. *Journal of Emerging Trends in Educational Research and Policy Studies*, 7(4), 212-217.

Omoju, O. E., & Abraham, T. W. (2014). Youth Bulge and Demographic Dividend in Nigeria: A Literature-Based Assessment. *African Population Studies*, 27(2), 352-360.

Papert, S. (1980). Mindstorms: Children, Computers, and Powerful Ideas. Basic Books.

Peshkin, M., & Colgate, J. E. (1999). Cobots. Industrial Robot: *An International Journal*, 26(5), 335-341.

Quigley, M., et al. (2009). ROS: An open-source robot operating system. *IEEE International Conference on Robotics and Automation*, 1-6.

Russell, S. (2019). Human Compatible: Artificial Intelligence and the Problem of Control. Viking.

Russell, S., & Norvig, P. (2020). *Artificial Intelligence: A Modern Approach* (4th ed.). Pearson.

Russell, S., & Norvig, P. (2021). Artificial Intelligence: A Modern Approach (4th ed.). Pearson.

Scharre, P. (2018). Army of None: Autonomous Weapons and the Future of War. W.W. Norton & Company.

Schneier, B. (2015). Data and Goliath: The Hidden Battles to Collect Your Data and Control Your World. W.W. Norton & Company.

Siciliano, B., & Khatib, O. (2016). Springer Handbook of Robotics. Springer.

Spong, M. W., Hutchinson, S., & Vidyasagar, M. (2005). *Robot modeling and control*. Wiley.

Topol, E. J. (2019). Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again. Basic Books.

Touretzky, D. S., Gardner-McCune, C., Martin, F., & Seehorn, D. (2019). Envisioning AI for K-12: What should every child know about AI?. *Proceedings of the AAAI Conference on Artificial Intelligence*, 33(1), 9795-9799.

Turing, A. (1950). Computing Machinery and Intelligence. Mind, 59(236), 433-460.

Valencia, L. C., Nguyen, N., & Thompson, P. (2016). Challenges in K-12 robotics education. *Journal of STEM Education*, 17(4), 15-20.

World Economic Forum. (2020). *The Future of Jobs Report*. Geneva: World Economic Forum.

Yang, G., Moore, J., & Glozman, D. (2020). Medical Robotics—Regulatory, Ethical, and Legal Considerations for Increasing Levels of Autonomy. Science Robotics, 5(49), eaaw2330.

Zhao, Y., & Watterston, J. (2021). The future of teacher education: Lessons learned from the pandemic. *Journal of Education for Teaching*, 47(1), 70-72.

GAMIFICATION AND GAME-BASED LEARNING FOR FOSTERING CRITICAL THINKING IN PHYSICS EDUCATION: STRATEGY TO REVITALIZE THE NIGERIA EDUCATION LANDSCAPE

Prof. Anikweze, Charles Maduegbuna
Faculty of Education
Paul University Awka, Anambra State, Nigeria
anikweze@yahoo.com ; 08036664269
and
Dr. Kanu, Abednego Chibuzo
Department of Science Education
Faculty of Education
University of Ilorin, Ilorin, Nigeria
kanu.ac@unilorin.edu.ng ; +2348036466111

Abstract

World technoscientific advancements have benefitted immensely from STEM education of which physics education is a subset. Demand for innovations regarding instructional delivery of scientific concepts and principles is expanding with globalization. Disappointingly, secondary school students in Nigeria have manifested aversion for physics due partly to unenchanting teaching-learning methodology. Consequently, career opportunities of STEM education suffer from insufficient subscription. Research evidence has shown that gamification and game-based learning are aspects of active learning methodologies generally advocated for their advantages. Learners have opportunities to develop critical-thinking and problem-solving skills, while providing pleasurable opportunities for dialogue, collaboration, competition and entrepreneurship. By incorporating game design elements as exemplified by the Anikweze model highlighted in the paper, physics educators can create engaging interactive experiences in students. It is recommended that physics teachers should enrich their classrooms with gaming activities to motivate and sustain learners' interests.
Key words: Gamification, Game-based learning, Critical thinking, Science education

Introduction

The role played by science education in transmitting scientific and technological knowledge, skills, attitudes and competencies from one generation of the populace to another cannot be over-emphasized. The robust workforce and innovations evidently reflected in the socio-economic transformation of nations are mainly due to science, technology, engineering and mathematics (STEM) education of which physics education is a pivotal branch. Adaji (2023) reported that despite the abundance of graduates who studied science-related courses such as physics, problems associated with scarcity of creative workforce have continued to slow down the development of robust industries and infrastructure in Nigeria. This situation could be attributed to foundational, philosophical and pedagogical deficit in the education system (Bowale & Ogundipe, 2022).

The poor attitude to learning science and perceived lack of interest in science-related subjects as displayed by learners at secondary school level leave much to be desired. Evidence of this pattern is manifested by the paucity of students opting for science subjects during streaming based on their expressed interests and future carrier choices. Some of the learners perceive science subjects (like Physics) as being complex to understand, uninteresting and full of abstract terms (Abenu & Yusufu, 2024). Constraints of complex scientific languages and

mathematical expressions used in most physics lessons make students perceive the subject as difficult to assimilate (Adeyemo, 2016). Persistent failure of physics students in public examinations is also a source of concern. It is possible there are other factors contributing to students' aversion for physics including scarcity of job opportunities for physics graduates outside teaching. Incidentally, many secondary school students in Nigeria overtly express dislike for teaching as a profession. Disappointingly, the few that manage to pass through the university physics courses graduate without basic practical and functional skills needed to solve individual and societal problems.

Among other instructional delivery methods and strategies, gamification and game-based learning methods with definable learning goals could be used to revitalize the Nigerian education landscape. Gamification according to Angelelli et al (2023) is adaptable for learners of all ages. This is made possible through interactive and engaging means offered by game-based teaching-learning methods. Afolabi (2020), and Kanu and Anikweze (2020), observed that traditional methods of science education have often failed to capture the interest of students, leading to high dropout rates, persistent failure in public examinations and a general apathy towards pursuing science-related careers. Moreover, achieving the number 4 Target of the United Nations' Sustainable Development Goals (SDGs) on the inclusiveness and harmonious distribution of quality education, and the promotion of life-long learning for all, might turn out a mirage if something drastic is not done to improve the educational landscape (UNESCO, 2021). Hence, the need for advocacy of innovative and more learner-engaging methods as offered by gamification.

Structure of the New Physics Curriculum in Nigeria's Educational Landscape

Physics is taught as one of the science subjects at the senior secondary school level in Nigeria, and its branches include mechanics, optics, electricity, atomic physics, physics of sub-atomic particles. The structure of the physics curriculum has been changed from the conceptual approach to the thematic approach and spiral to content organization (NERDC, 2012). The thematic approach ensures the curriculum aligns with national and global issues without necessarily overloading the contents while addressing the unique educational needs of the country. (Omosewo, Akanbi & Mohammed, 2016). Three factors have been stressed in the philosophy of the physics curriculum as contained in the senior school physics curriculum, namely: understanding of concepts, functionality and application. It aims to equip students with both theoretical knowledge and practical skills necessary for solving real world problems. The curriculum covers a broad range of topics, including mechanics, electricity, magnetism, thermodynamics, and modern physics, all providing a comprehensive understanding of the subject. The six themes as affirmed by Omosewo et al. (2016) in the new physics curriculum with related topics and contents are:

i. Interaction of matter, space and time
ii. Conservation principles
iii. Waves: motion without materials transfer
iv. Field at rest and in motion
v. Energy quantization and duality of matter
vi. Physics in technology

Critical Thinking as a Core Goal of Physics Education

Critical thinking is a core goal necessary for problem-solving and decision-making in physics education. It is a cognitive operating system that engages learners to create immersive, multi-dimensional interactive learning experience. Critical thinking has to do with identifying a subject, assigning points of views, and encouraging learners to use their reasoning skills to

arrive at a sound and rational argument to succeed. In its simple form, and according to Drimify (2025) demo, critical thinking is asking questions and forming judgements based on an unbiased analysis of available evidence. To practice critical thinking is to approach a problem, ask the right questions, seek out the best available evidence, consider and debate alternative points of view and make viable recommendations. Critical thinking in a game is a subjective process which involves the sharing and discussion of opposing viewpoints. It appeals to curious players using results to foster debate and discussion. Innovators and entrepreneurs of tomorrow need critical thinking developed through educational games.

Gamification and Game-based Approach as Pedagogical Tool to Foster Critical Thinking

As a pedagogical tool, gamification and game-based teaching-learning strategy have the tendency to enhance motivation, engagement and development of cognitive skills in learners. Gamification is an ideal vehicle and tool to bring critical thinking skills into the classroom for learners of all ages (Drimify 2025). At any level, critical thinking demands intellectual efforts which help to exercise the brain. Gamification fosters scientific thinking by situating learning in real-world contexts, enabling learners to behave and act as scientists capable of solving complex problems. Games can often be analogue or digital; and capable of incorporating simulations and role play of real-life experiences to support either or both of formal, non-formal and informal education (Angelelli et als, 2023). The growing popularity of gamification is an offshoot from the belief in its potential to foster motivation, behavioural changes, friendly competition and collaboration in different contexts, such as customer engagement, employee performance and social loyalty (Dichey & Dicheva, 2017). Gamification has the characteristics of being competitive making use of mental and social skills, marked by chance and clearly defined issues and viewpoints. Other remarkable features of gamification include being clearly rewarding and characterized by regular, orderly progress towards a specified and realistic goal.

In a gamified classroom, students play the game together; they learn from the game and from each other, developing their critical thinking skills as they explore, research and exchange information, discovering the who, what, when, where and how of things in pursuit of their goals within the game. Thus, through gamification, students learn and execute increasingly complex scaffolded tasks within a specified time in pursuit of a particular goal, which marks the end of the class. Dwyer (2018) successfully used gamification to develop an engaged pedagogy and solve the problem of retention associated with students' unfamiliarity with contexts. Gamification and simulations have emerged as innovative techniques that lever the classroom instruction from 'teacher-talk and pupils-listen' situation to more participatory and gainful classroom experiences. These innovative techniques usher in novelty and activity into the teaching-learning process and at the same time facilitate the understanding of remote, abstract and often risky phenomena by substituting realities with more immediate, familiar and safe experiences (Drimify (2025). A simulation is a situation involving students in role model playing the part of decision makers. It is an operating model which possesses a high degree of similarity with reality and yet is a reduction and abstraction of reality.

One of the earliest experiments with gamification was carried out by Anikweze in 1988 at the University of Nigeria, Nsukka (Anikweze, 1992). He designed what he called Anikweze Model of Instruction for Teaching Geography (AMITEG). The study involved the use of Instructional Models, Games and Simulations for experimental study of topics chosen from senior secondary school geography syllabus including ecosystem and migrations. The

AMITEG was an adapted form of Concept Attainment Model of teaching developed by Brunner and others in 1956. Theoretically therefore, the AMITEG belongs primarily to Information Processing–oriented Models which emphasize development of inductive reasoning, creativity and general cognitive ability. At the same time, the strategies involved in the use of games and simulation borrowed some tactics from the Social Inquiry Model which itself emphasizes problem-solving through academic enquiry and logical reasoning while providing for social interaction among learners.

In terms of impact, it is discernible that the focus of the AMITEG is dual. First, it provides for maximum pupil participation in problem-solving either interacting as individuals in groups/teams. This perspective ensures attainments in the cognitive domain. Secondly, the model provides for social interaction (pupil-teacher and pupil-pupil) in a semi-informal environment where emotions, feelings, thinking, action and self-fulfillment are merged with academic pursuit. This part of the focus emphasizes learning in the affective domain as much as development of thought processes. Both of these characteristics of gamification are reproducible in the teaching and learning of physics education.
The greatest impact of the AMITEG as a teaching model lies in the social system which comprises two aspects of dramatis personae in a teaching-learning process: the teacher and the learners. The AMITEG social system provides for specified teacher roles and learner activities in the five progressive stages of lesson development. A similar social system could be applied in a gamified physics lesson. This is exemplified with the following graphical illustration (Figure 1).

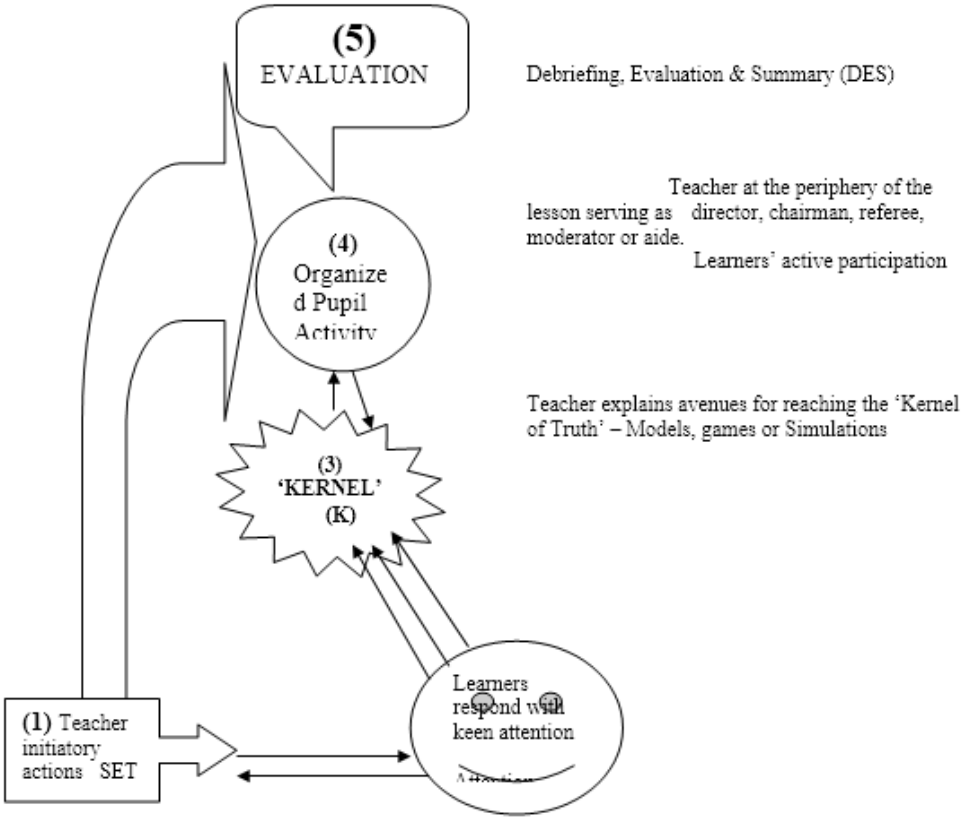


Figure 1: Anikweze Model of Instruction for Teaching Geography (AMITEG) Stage 1

The teacher with a package of learning outcomes pitches at the bottom of the class in a mixed-ability system of streaming. Teacher introduces the topic and the expected learning outcomes as achievable specific objectives.

Stage 2

Teacher throws 'search light' to link pupils' entry behaviour to new topic. Any strategy for set induction could be adopted but essentially the teacher must have a charm for arousing the interest and motivation of the learners. The teacher goes ahead to usher in new basic ideas, concepts and skills as challenges to be overcome by learners. Learners are expected to respond with keen interest due to the novelty ushered in by the active learning approach.

Stage 3

Teacher explains avenues for reaching the 'Kernel of Truth' (K), that is, the planned instructional objectives plus any other chance learning outcome. New concept is embedded in the operational material or movement. Teacher presents operational material(s) or movement either as a model, a game or a simulation.

a) As a symbolic model, the teacher provides advance organizers to guide learners' discussion or community of inquiry.
b) As a game, the teacher defines goal(s), explains roles of players and issues guiding rules.
c) As a simulation, the teacher defines roles and establishes circumstances under which participants would function.

Stage 4

Organized Pupil Activity (OPA) - Pupil participation could be in form of individual or group contributions. The teacher at this stage serves as director, chairman, referee, moderator, aide or supervisor, allowing as much initiative as essential from pupils. Though in the peripheral of the lesson at this stage, teacher guards against collapse, sabotage and disaster. Collapse occurs when there is loss of control of pupils' emotions, actions and reactions leading to indiscipline in the class. Sabotage is a hitch on the movement of a lesson or in pupils' participation due to inability of any pupil(s) to act or contribute as directed either because of improper conception of role, or due to poor motivation. Disaster is a misdirection of pupil energies leading up to unwanted results and failure to achieve the stated objectives of instruction.

Stage 5

Debriefing, Evaluation and Summary (DES) – Teacher and learners appraise the topic and the extent of achievement of the objectives and try to resolve the problems encountered during the OPA. This implies any appropriate strategy for achieving closure which include asking evaluation questions and building up chalkboard summary from the pupils' answers; identifying unresolved issues emanating from OPA and assigning them with guidance to pupils as take-home tasks; post-activity discussion; and evaluation of activity experience. An example of a game-based lesson is provided herein and although it is for a social science, yet the sequence in replicable any properly designed science-based subject including physics.

USE OF GAME FOR TEACHING INTERNAL MIGRATIONS

TOPIC: Internal migrations
Class: S. S. III
Ability: Mixed
Sex: Mixed
Time: 70 minutes

Previous Knowledge: Students are familiar with the seasonal migration of the cattle Fulani.
Teaching Aid: Equipment for Migrations Geographical Game (Figure 2 and some dice).

General Objective: At the end of the lesson, the student will appreciate the circumstances under which people migrate to permanent or temporary places of abode within the country.

Specific Objectives: After participating in the Migration Geographical Game, the student will be able to:

(i) Correctly explain the terms: internal migration, pull factor, push factor, rural, urban and migrant.
(ii) Classify internal migrations according to source - destination with relevant examples.
(iii) Explain five factors that influence internal migration in Nigeria.
(iv) Analyze five problems associated with rural-urban drift of population in Nigeria.
(v) Relate categories of migration to differential factors such as age, sex, family status/size and vocation.
(vi) Suggest four logical steps that could be taken to prevent rural – urban drift.

Introduction: Induce set by explaining the terminal objectives of the lesson to the students. Provoke their thought by asking them to explain why it is possible for any of the Nigerian languages to be heard being spoken at places other than the 'home' of such a language. The students' responses will lead to the realization that diffusion of different tribal cultures including languages in Nigeria occur due to internal migrations by those who speak such languages.

Presentation:

Stage I: Explain the concept of internal migration as different from external or international migration. Using relevant examples, emphasize that internal migrations could be permanent or temporary (seasonal or irregular). It could also be spontaneous, forced or planned by the government. Distinguish between circulation of population and actual migration. The former refers to daily or periodic movements of people from their homes to places of interest and back e.g. movement of labourers, traders, cultivators, civil servants, students, hunters, etc. The later requires the migrant to move with all or most of his/her belongings.

Stage II: Introduce the Migrations Geographical Game and explain the basic ideas to be learnt from the game, e.g. push and pull factors, the type of migrations according to source and destination, and the various categories of migrants which the students would simulate in playing the game.

Brief the pupils on the rules of the game and the tasks to reflect upon as they play the game. These tasks include the circumstances that 'push' or 'pull' the migrants and the problems they encounter in moving from one area to another.

MIGRATIONS GEOGRAPHICAL GAME

The game 'Migrations' is a simulation of population movements in a region such as Nigeria. The game attempts to expose the 'push' and 'pull' factors that influence internal migration. In terms of destination, four patterns of migratory movement are represented in the game. These are the rural-rural, rural-urban, urban-urban, and urban-rural. The various categories of migrants are highlighted. Some of the problems associated with migrations are also reflected while providing the players with leisure and amusement.

'Migrations' is dice game which can be played by as many 'migrants' as there are distinguishable seeds. The game starts with the migrants or players throwing the dice in turns. Players whose first throw brings out odd numbers are rural migrants while those with even numbers simulate urban migrants. The movements of their seeds are as indicated by arrows on the board.

(**NOTE**: The rural migrants are the labourers involved in farm work, the pastoral nomads, hunters, and itinerant rural traders. The urban migrants are the civil servants, members of the armed forces, students, unemployed graduates, traders and businessmen.)

In playing the game, the seeds of the migrants move in order of the numbers on the board but adhering strictly to the rules of the game. The rules represent the socio-economic factors that induce migrations. The last player to arrive at the permanent settlement is the most mobile migrant and would be crowned the '**rolling stone**'.

RURAL RULES

1. Any migrant that arrives at 10 should move into the Village Resort or Refugee Camp. The Village Head shows the migrant a place to stay for two months. The Player losses two chances before migration resumes from the camp.
2. At 11, you are recruited into the forces. Move straight to 'Urban to Urban' 11 for training.
3. At 14, your rural settlement is displaced by government-planned project such as a dam and artificial lake, new capital, airport or university site. Move into the New Village for permanent settlement i.e. the player is out of the game.
4. At 15, you arrive at the Rural Area Base (RAB). The rural community welcomes you warmly. Stay and engage in your trade for two months, that is, loss of two chances, after which migration continues. If the next throw is a six, then the migrant moves directly into the urban area for a larger scale business at Urban 15.
5. Any migrant that lands at 18 is an animal rearer. He discovers that climatic conditions are unfavourable for his cattle. Availability of water and pasture attract the migrant and his herd to12.
6. At 20, the migrant arrives at a village with a large rural market. He sojourns for sometime selling his commodity to raise enough money for migration into an urban area. The player enjoys two throws at each turn till he gets a five before the seed moves out of 20.
7. At 22 the migrant clashes with villagers for trespassing and destroying farm crops. To avoid bloodshed, move back four spaces.
8. Any migrant that arrives 25 has qualified socially and economically to fit into urban life. Player should move directly to Urban 25.
9. At 30, player moves into permanent rural settlement to engage in farming. Beyond 25, players could wait for appropriate numbers to enter 30.

URBAN RULES

1. At 8? Sorry, there is no job and no accommodation for you in the town. Go back to the starting point.
2. At 10, you enter and relax in any of the big hotels or the "Destitute Camp" if you are poor. You have three chances to get out with a throw of six, otherwise transfer to Rural Refugee Camp.
3. At 12, residence is demolished, business fails and workers are retrenched. The only option is to migrate to rural area 12 to farm.
4. At 14, single lady settles down with her husband. Go straight into permanent urban settlement.
5. At 17, religious riot forces you to migrate to rural 10. You are welcome as a refugee.
6. A19, your unit (police or army) has been moved to rural 14 to maintain peace. Move out and join them.
7. At 20, your employer sends you for in-service training. Move into the college for two years, i.e. loss of two chances at play. When course is completed move to 24.

8. At 21, you are arrested for idleness and malingering and sent into the camp for destitute. Loss of two playing chances.
9. At 24, you arrive at the NYSC Headquarters. You stay for one-month orientation before deployment (loss of one chance). If your next throw is an odd number, your posting is to rural 15, but if an even number, you go to urban 15.
10. At 25, you must not get either one or six, but if you do, then you go backwards by that number.
11. A migrant that arrives at 26 is appointed supervisor for the zonal agricultural project at rural 16. Move to your station.
12. At 30, there is retirement from active service whether civil or military. If the next throw yields an odd number, you retire into the village resort, but if an even number you retire into permanent urban settlement.

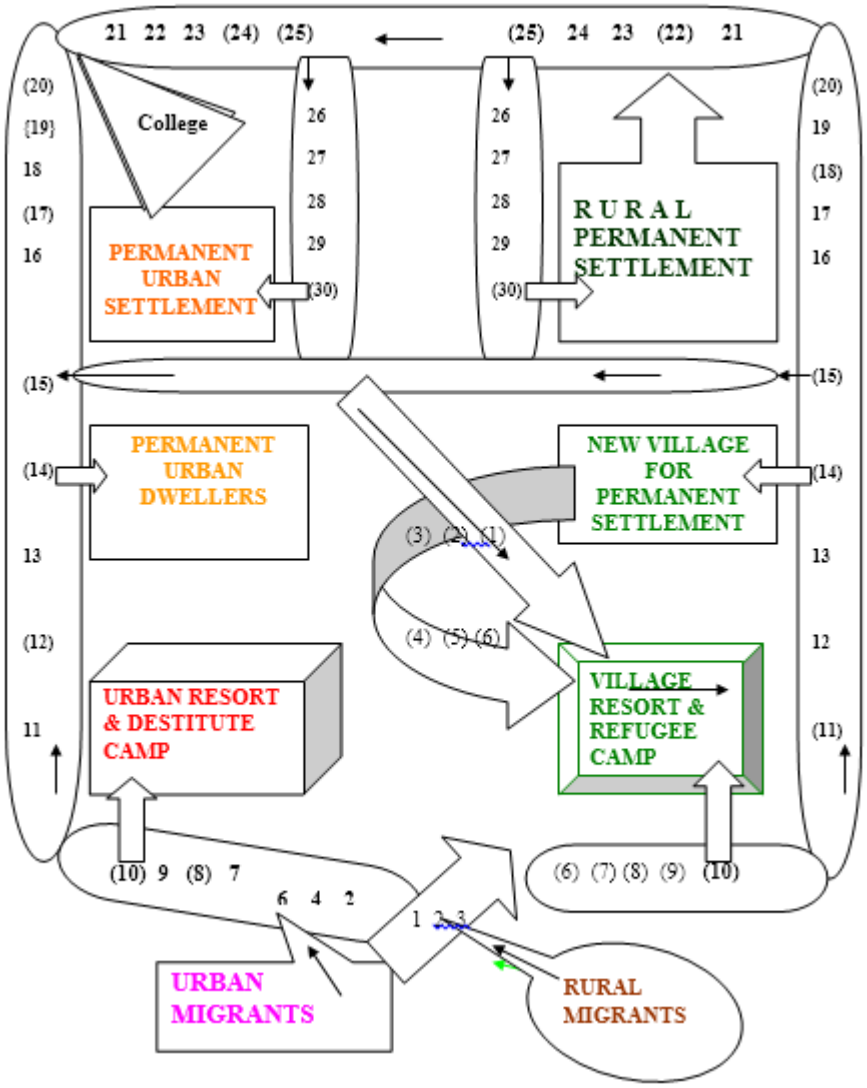


Figure 2: Migrations Instructional Game, Adapted from Anikweze (1988)

Conclusion and Recommendations

Gamification and game-based learning methods could have significant implications for revitalizing Nigeria's educational landscape leveraging on the power of interaction among learners and with capacity to improve students' learning outcomes, increase motivation and promote conceptualization of learning experiences.

It is recommended that science educators and policymakers integrate gamification and game-based learning into physics curricula and instructional practices. To achieve this ideal, practicing pre-service physics teachers should receive professional training and re-training opportunities on game design, development and implementation. Furthermore, educational institutions in Nigeria should invest in infrastructure and resources targeted at supporting game-based learning such as simulations, virtual realities technologies and educational games. In addition, research efforts and evaluation should be intensified and refined to improve gamification and game-based learning strategies with the expectation of ensuring effectiveness in diverse educational contexts. Teachers of physics education should endeavour to always create a conducive classroom environment that provides relevant activities for learners. Such an environment should be guided by some norms or standard patterns of behaviour that provide for equal opportunity. During game-based learning, seating arrangement should be flexible to allow adequate space for each type of activity. All needed equipment and materials should be readily available and there should be adequate briefing including rules/instructions for the tasks before the start of activities. The briefing should include safety precautions to prevent accident. While 'noise' and excitement may be permissible, they should be controlled to prevent collapse of the lesson. Finally, in group games, the teacher should adopt inclusiveness by assigning students to groups based on justifiable rationale of a mix of 'strong' and 'weak' ones, but allowing them to choose their own group leaders.

References

Abenu, A. & Yusufu, F. A. (2024) An appraisal of teachers' professional development in the Federal Capital Territory, Abuja-Nigeria. *Nepal Journals Online, 2*(1). https://www.nepjol.info and DOI: https://doi.org/10.3126/fwr.v2i1.70492

Adaji, B. O. (2023) *What I did not learn in school*. Published by Sonia Computers. Kaduna

Adeyemo, S. A. (2016). Teaching/learning of physics in Nigerian secondary schools: the curriculum transformation, issues, problems and prospects. *International Journal of Education and Technology, 1*(1), 99-111. Published by Society of Education, India. http://www.soeagra.com

Afolabi, M. A. (2020) An appraisal of the national basic science and technology curriculum in Nigeria: a case study of Federal Capital Territory (FCT) Abuja. *Academic Staff Union of Research Institute (NERDC Branch)*. URL: https://www.asurinerdc.org

Angelelli, C. V., Ribeiro, G. M., Severino, M. R, Johnstone, E., Borzenkova, G. & Oliveira da Silva, D. C. (2023) Developing critical thinking skills through gamification. *Elsevier, 49(2023) 101354*. https://doi.org/10.1016/j.tsc.2023.101354 or https//www.sciencedirect.com and https://pubmed.ncbi.nim.nih.gov

Anikweze, C. M. (1992) Improving the study of geography in Nigerian secondary schools through the use of models, games and simulations. *TNTT Journal of Teacher Education, 1*(2), 159-166. National Commission for Colleges of Education

Anikweze, C.M. (1988). *Evaluating the Effectiveness of the Use of Models, Games and Simulations for Teaching Geography in Nigerian post primary schools.* Unpublished Ph, D. Thesis submitted to the Faculty of Education, University of Nigeria, Nsukka.

Bowale, E. B. & Ogundipe, C. A. (2022) Assessment of Basic science and technology curriculum implementation in lower primary schools in Ondo state, Nigeria. *International Journal of Contemporary Issues in Education 4*(1)

Dichey, C. & Dicheva, D. (2017) Gamifying education: what is known, what is believed and what remains uncertain: a critical review. *International Journal of Educational Technology in Higher Education 14*(9). https://doi.org/10.1186/s41239-017-0042-5

Drimify Demo (2025) Gamifying the development of critical thinking in education. *Gamification Resources – Drimify demo/platform*. URL: drimify.com

Dwyer, S. (2018). Gameful engagement: gamification, critical thinking, and first-year composition. *Double Helix, 6*(2018). Digital Commons @ Texas A & M University – San Antonio. https://digitalcommons.tamusa.edu/engl-faculty, DOI: 10.37514/DBH-J.2018.6.1.07

Kanu, A. C**. &** Anikweze, C. M. (2020). Effects of inquiry strategy on achievement and retention of basic science and technology among students in Karu LGA, Nasarawa State, Nigeria. *Journal of Innovations in Educational Assessment, 2*(2), 37-53. Published by International Association for Innovations in Educational Assessment (IAIIEA). https://uilspace.unilorin.edu.ng/handle/123456789/14845

Nigerian Educational Research and Development Council (NERDC). (2012). *9-Year basic education currriculum.basic science & technology* for js1 – js3.

Omosewo, E. O., Akanbi, A. O. & Mohammed, R. E. (2016). Problems and prospects of teaching physics in senior schools in Nigeria. E. O. Omosewo (Ed.). *Methods of Teaching Physics*, 161-163. Published by Faculty of education, University of Ilorin, Ilorin, Nigeria.

UNESCO (2021) Unpacking Sustainable Development Goal4 SDG's 10 Targets. In *Global campaign for education*. Downloaded www.campaignforeducation.org

UTILISATION OF DIGITAL SKILLS AND ARTIFICIAL INTELLIGENCE (AI) ON TVET FOR ECONOMIC DIVERSIFICATION IN 21ST CENTURY EDUCATION LANDSCAPE IN NIGERIA

SHAMSUDDEEN IBRAHIM UMAR PhD
shamsuddeeniumar@gmail.com
08039297081
DEPARTMENT OF SECURITY MANAGEMENT AND TECHNOLOGY
KATSINA STATE INSTITUTE OF TECHNOLOGY AND MANAGEMENT (KSITM)
NIGERIA

Abstract

The study investigated the utilization of digital skills and Artificial Intelligence (AI) on TVET for economic diversification in 21st century education landscape. The 21st century has brought about unprecedented changes in the global economy, driven by technological advancements and shifting workforce demands (World Bank, 2020). Technical and Vocational Education and Training (TVET) has emerged as a crucial driver of economic diversification, as it equips individuals with skills tailored to industry needs. This paper explores the integration of digital skills and Artificial Intelligence (AI) in TVET, highlighting its potential to foster economic diversification in the 21st century education landscape. It offers a thorough assessment of chosen materials on digital skills and artificial intelligence in education released lately (mainly from 2010 to date), as gathered in the Web of Sciences database and selected specialized publications, from distinct educational viewpoints. In addition, the article defines both Artificial intelligence and Digital skills terminologies and some relevant sub – fields such as the Role of Digital Skills in TVET, the Impact of AI on TVET, Economic Diversification through TVET Challenges and Future Directions among others. It suggests and recommended among others that, government should invest in infrastructure and resources, Develop teacher training programs, Promote industry partnerships and Ensure equity and access.

Key Words: Utilization, Digital Skills, Artificial Intelligence (AI), TVET, Economic Diversification

Introduction

Digitalization has led to extensive changes in the skills required for work and life. For technical and vocational education and training (TVET) institutions to remain relevant and attractive, they need to identify and introduce digital skills and competencies for the changing world of work, and to better utilize the opportunities provided by digitalization, particularly distance learning. Their success in harnessing the benefits and tackling the challenges of digitalization largely depends on the digital capabilities of TVET teachers and trainers. Teachers and trainers face multiple challenges to keep up with the latest digital transformations and to upgrade their skills to apply modern technology-aided instruction. Likewise, managers of TVET institutions are hindered by the lack of support in creating enabling digital environments and building innovative institutions(UNESCO 2022). Today digitalskills and Artificial Intelligence (AI) on TVET for economic diversification remain under-utilization in 21st century education landscape in Nigeria.

A thorough assessment of recent studies on digital skills and AI in education reveals the growing importance of these technologies in shaping the future of work. According to the

World Economic Forum (2020), digital skills are essential for workers to remain relevant in the job market. Similarly, AI has the potential to transform TVET by enhancing the learning experience, improving assessment and feedback, and providing personalized learning pathways (Farias & Rochester, 2019).

The Role of TVET in Economic Diversification

TVET had been defined by Ukala and Iheukwumere (2025) as all forms and aspects of education that are technical and vocational in nature, provided either in educational institutions or under their authority, by public authorities, the private sector or through other forms of organized education, formal or non-formal, aiming to ensure that all members of the community have access to lifelong learning.

The objectives of TVET according Federal Republic of Nigeria (FRN) (2014:14) are to:

1. Provide trained manpower in applied science, technology and commerce particularly at sub-professional level;
2. Provide the technical knowledge and vocational skills necessary for agricultural, industrial, commercial and economic development;
3. Provide people who can apply scientific knowledge to the improvement and solution of environmental problems for the use and convenience of man;
4. Give an introduction to professional studies in engineering and other technologies;
5. Give training and impart the necessary skills leading to the production of craftsmen, technicians and other skilled personnel who will be enterprising and self-reliant; and
6. Enable young men and women to have intelligent understanding of the increasing complexity of technology.

As the landscape of work is undergoing rapid transformation, primarily driven by digitalization and automation; Information technology are redefining essential skills for workers, emphasizing not only traditional competencies but also the increasing necessity for new, transversal skills. The relationship between Technical and Vocational Education and Training (TVET) and Artificial Intelligence (AI) is increasingly significant as AI technologies reshape industries and labor markets in so many ways such as: enhancing skill development through adaptive learning, and intelligent tutoring systems (ITS); industry-relevant training by using AI-driven models to predict for workforce readiness; entrepreneurship and creativity; team work and collaboration.

Maseko (2024) revealed that there is a notable increase in the demand for specific technical skills, STEM skills, and training on ICT/digital and 3D technologies for TVET teachers and trainers.TVET plays a critical role in equipping individuals with the skills required to drive economic growth and diversification (UNESCO, 2019). By providing training in specific skills and competencies, TVET enables individuals to contribute to various sectors of the economy. TVET isacronyms which stand for Technical and Vocational Education and Training.

T - Technical

i. Refers to the specialized knowledge and skills required in specific technical fields such as engineering, information technology, or applied sciences (UNESCO, 2019).
ii. Focuses on practical applications of scientific and technological principles (European Commission, 2020).

V - Vocational

i. Pertains to education and training that prepares individuals for specific occupations or careers, particularly in skilled trades, crafts, or technical fields (ILO, 2019).

ii. Emphasizes the development of practical skills and competencies that are directly applicable to the workplace (OECD, 2019).

E - Education

i. Refers to the structured process of teaching and learning technical and vocational skills (UNESCO, 2019).
ii. Involves both theoretical knowledge and practical training to ensure a well-rounded understanding of the subject matter (World Bank, 2020).

T - Training

i. Focuses on the development of specific skills and competencies through hands-on practice and instruction (ILO, 2019).
ii. Aims to equip individuals with the ability to perform tasks efficiently and effectively in a real-world work environment (European Commission, 2020).

Key Features of TVET

- ✓ Practical Focus: TVET emphasizes hands-on learning and real-world application of skills (UNESCO, 2019).

Industry Relevance: Programs are often designed in collaboration with industry partners to ensure alignment with current job market needs (World Bank, 2020).

- ✓ Career Preparation: TVET aims to prepare individuals for specific careers or occupations, enhancing their employability and potential for advancement (ILO, 2019).

Importance of TVET

- Economic Growth: TVET contributes to economic development by providing a skilled workforce that meets the needs of various industries (World Bank, 2020).
- Employment Opportunities: TVET programs enhance employability and provide individuals with the skills needed to secure jobs or start their own businesses (ILO, 2019).
- Innovation and Productivity: By focusing on practical skills and industry relevance, TVET helps improve productivity and innovation in the workplace (OECD, 2019).

Digital Education/literacy

Some authors' view that digital literacy cannot be limited to certain digital skills but also is linked to a wider and, more critical view of the given society in this era of technological revolution. Ferrari (2012) proposed the following definition of digital competence as:

> "the set of knowledge, skills, attitudes (thus including strategies, values and awareness) that are required when using ICT and digital media to perform tasks; solve problems; communicate; manage information; collaborate; create; share content; and build knowledge effectively, efficiently, appropriately, critically, creatively, autonomously, flexibly, ethically, reflectively for work leisure, participation, learning, socializing, consuming and empowerment(Ferrari 2012)."

In general, digital competence can also be defined as "the creative, critical and confident use of information and communication technologies to achieve the objectives related to work, employability, learning, leisure, inclusion, and participation in the society." Thus, a 'model framework', individual competences are group into five key competence areas', they are:

i. Information and data literacy,
ii. Communication and collaboration,
iii. Digital content creation,
iv. Safety and
v. Problem solving.

Digital Education/Literacy Tools and Differential Mode of Operation

Hundreds of digital education tools (DET) have been created and identify with the purpose of giving autonomy to the student, improving the administration of academic processes encouraging collaboration and facilitating communication between the teachers and the learners (Chauhan, 2018). The following were discussed by him, thus:

- **Edmodo:** This is educational tool that connect teachers and students, and is assimilated into a social network. In this one teacher can create online collaborative groups, administer and provide education materials, measure student performance; and communicate with parents, among other functions.
- **Socrative:** Designed by group of entrepreneurs and engineers passionate about education, socrative is a system that allows teachers to create exercises, or educational games which student can solve using mobile devices, whether Smartphones, laptops or tablets.
- **Projeqt:** Is a tool that allows you to create multimedia presentations, with dynamic slides in which you can embed interactive maps, links, online quizzes, Twitter timelines and videos among other options.
- **TED-Ed:** Is a platform that allows creating educational lessons with the collaboration of teachers, students, animators……generally people who want expand knowledge and good ideas. This website allows democratizing access to information, both for teachers and students.
- **Educlipper:** This platform allows teachers and students to share and explore references and education materials. In educlipper you can collect information found on the internet and then share it with the members of previously created groups, which offers the possibility to manage more effectively the academic content found online, improve research techniques and have a digital record of what students achieved during the course.
- **Kahoot:** Is platform that is based on games and questions. Through this tool, teachers can create questionnaires, discussion or surveys that complement academic lessons. The material is projected in the classroom and questions are answered by the students while playing and learning at the same time. It promotes game-based learning, which increases students engagement and creates a dynamic, social and fun educational environment.
- **Room 21:** Is a 21st century social learning platform. It is a Facebook-like environment designed for peer collaboration and to create learning communities online (Falade and Alimi 2015).

These digital tools could be of great relevance to lecturers and teachers if put in to use due to the fact that students are increasingly becoming well versed in modern communication technology and this would lead and result to economic diversification in 21st century education landscape as supported by Himmelsbach (2019), who opined that "student are digital natives."

Digital Skills in TVET

Digital skills have become essential in the modern workforce (European Commission, 2020). Digital skills are critical for TVET students to acquire, as they enable individuals to access, create, and communicate information effectively. The integration of digital skills in TVET can enhance employability, productivity, and innovation (European Commission, 2020). Some of the key digital skills that can be incorporated in TVET include:

1. Data analysis: The ability to collect, analyzes, and interprets large data sets to inform decision-making.
2. Digital literacy: The ability to use digital tools and technologies to communicate, collaborate, and access information.
3. Programming and coding: The ability to design, develop, and implement software applications and systems.
4. Cyber security: The ability to protect digital systems and networks from cyber threats.

Definition of Digital Skills

Digital skills refer to the abilities and knowledge required to effectively use digital technologies, such as computers, smartphones, and software, to access, create, and communicate information (European Commission, 2020).

Types of Digital Skills

Digital skills encompass a range of competencies, including:

i. Basic Digital Skills: Digital literacy, online navigation, and communication (Van Deursen & Van Dijk, 2014).

a. Digital literacy: The ability to use digital devices and basic software applications.
b. Online navigation: The ability to effectively use the internet, search engines, and online platforms.
c. Communication: The ability to use digital tools for communication, such as email, messaging, and video conferencing.

ii. Intermediate Digital Skills: Data analysis, content creation, and digital collaboration (OECD, 2019).

a. Data analysis: The ability to collect, analyze, and interpret digital data.
b. Content creation: The ability to create digital content, such as writing, graphics, and multimedia.
c. Digital collaboration: The ability to work collaboratively with others using digital tools.

iii. Advanced Digital Skills: Programming and coding, cybersecurity, and data science (World Economic Forum, 2020).

a. Programming and coding: The ability to design, develop, and implement software applications and systems.
b. Cybersecurity: The ability to protect digital systems and networks from cyber threats.
c. Data science: The ability to extract insights and knowledge from large datasets using advanced statistical and computational techniques.

Importance of Digital Skills

Digital skills are essential in today's digital age, as they enable individuals to:

i. Access information: Digital skills allow individuals to access vast amounts of information and knowledge (Castells, 2009).
ii. Communicate effectively: Digital skills enable individuals to communicate effectively with others, both personally and professionally (Katz & Krueger, 2016).

iii. Participate in the digital economy: Digital skills are necessary for individuals to participate in the digital economy, including online shopping, banking, and entrepreneurship (World Bank, 2016).
iv. Enhance employability: Digital skills are highly valued by employers, and having these skills can enhance an individual's employability and career prospects (Bakhshi *et al.*, 2017).

AI in TVET

Artificial Intelligence (AI) refers to the development of computer systems that can perform tasks that typically require human intelligence, such as learning, problem-solving, reasoning, perception, and language understanding (Russell &Norvig, 2010).

Types of AI

1. Narrow AI: Designed to perform a specific task, such as facial recognition or language translation (Kurzweil, 2005).
2. General AI: Possesses human-like cognitive abilities, enabling it to understand, learn, and apply knowledge across various tasks and domains (Kurzweil, 2005).

Applications of AI

i. Healthcare: AI can analyze medical images, diagnose diseases, and develop personalized treatment plans (Esteva *et al.*, 2019).
ii. Finance: AI can detect anomalies in financial transactions, predict stock prices, and optimize investment portfolios (Dixon *et al.*, 2020).
iii. Transportation: AI can enable self-driving cars to navigate roads, recognize obstacles, and make decisions in real-time (Ma *et al.*, 2019).

Benefits of AI

1. Automation: AI can automate repetitive tasks, freeing up human time for more strategic and creative work (Frey & Osborne, 2017).
2. Improved Decision-Making: AI can analyze vast amounts of data, providing insights and predictions to inform decision-making (Jordan & Mitchell, 2015).

Challenges and Limitations of AI

- Bias and Fairness: AI systems can perpetuate biases present in the data used to train them, leading to unfair outcomes (Kluwer, 2020).
- Explainability: AI systems can be difficult to interpret, making it challenging to understand their decision-making processes (Adadi&Berrada, 2018).

AI has the potential to revolutionize TVET by providing personalized learning support, automating assessment and feedback, and enhancing the learning experience. AI-powered systems can also help to identify skills gaps and provide recommendations for improvement (OECD, 2019). Also AI has the potential to transform TVET (Farias & Rochester, 2019). Some of the ways AI can be integrated in TVET include:

- ✓ Intelligent tutoring systems: AI-powered systems that provide personalized learning support and feedback to students.
- ✓ Virtual reality and simulation: AI-powered virtual reality and simulation environments that mimic real-world scenarios, enabling students to practice and develop skills in a safe and controlled environment.
- ✓ Automated assessment and feedback: AI-powered systems that automate assessment and feedback, freeing up instructors to focus on teaching and mentoring.

Economic Diversification through TVET

Economic diversification refers to the process of shifting an economy's focus from a single industry or sector to a variety of industries or sectors. This strategy aims to reduce dependence on one particular source of income, enhance economic resilience, and promote sustainable growth (World Bank, 2020).

Key Aspects of Economic Diversification

i. Reducing Dependency: Decreasing reliance on a single industry to mitigate risks associated with market fluctuations (Auty, 1993).
ii. Promoting Innovation: Encouraging the development of new industries and sectors through innovation and entrepreneurship (Schumpeter, 1942).
iii. Creating Employment: Generating job opportunities in diverse sectors to reduce unemployment and improve livelihoods (ILO, 2019).
iv. Enhancing Competitiveness: Building a more competitive economy by fostering a variety of industries that can adapt to global market demands (Porter, 1990).

TVET plays a critical role in driving economic diversification by equipping individuals with skills tailored to industry needs. The integration of digital skills and AI in TVET can enhance the employability of graduates, improve productivity, and drive innovation (World Bank, 2020).

Benefits of Economic Diversification

i. Increased Resilience: Diversified economies are better equipped to handle economic shocks and external pressures (World Bank, 2020).
ii. Job Creation: New industries and sectors create employment opportunities, reducing unemployment rates (ILO, 2019).
iii. Sustainable Growth: Diversification promotes long-term economic stability and growth by reducing reliance on volatile sectors (IMF, 2019).
iv. Innovation and Competitiveness: Encourages innovation and enhances the economy's ability to compete globally (OECD, 2019).

Challenges in Achieving Economic Diversification

- Infrastructure Development: Requires investment in infrastructure, such as transportation, energy, and digital networks (World Bank, 2019).
- Workforce Skills: Developing a skilled workforce capable of adapting to new industries and technologies (OECD, 2019).
- Policy and Regulation: Effective policies and regulations are needed to support new industries and attract investment (World Bank, 2020).
- Market Access: Access to domestic and international markets is crucial for the success of diversified industries (WTO, 2020).

Benefits of Digital Skills and AI in TVET

If government can engage and implement action plan on the integration of digital skills and AI in TVET, they can lead to numerous benefits, including improved employability, increased productivity, and innovation (OECD, 2020).

Challenges and Future Directions/ Opportunities

Despite the potential benefits of digital skills and AI in TVET, there are several challenges that need to be addressed, including:

i. Infrastructure and access: Ensuring that TVET institutions have the necessary infrastructure and access to digital technologies.

ii. Teacher training: Providing instructors with the necessary training and capacity building opportunities to develop their digital skills and AI competencies.
iii. Industry partnerships: Fostering partnerships between industry and TVET institutions to ensure that graduates are equipped with the skills required by industry (World Economic Forum, 2020).

Future research should focus on exploring the impact of digital skills and AI on TVET outcomes and identifying effective strategies for implementation.

Conclusion

The utilization/integration of digital skills and AI in TVET has the potential to drive economic diversification and growth. By investing in infrastructure and resources, developing teacher training programs, promoting industry partnerships, ensuring equity and access, collaboration between policymakers, educators, and industry stakeholders is crucial to harnessing this potential. Governments can support the effective implementation of digital skills and AI in TVET.

Recommendations

Based on this paper, the following recommendations are made:

1. Integrate digital skills and AI in TVET curricula: TVET programs should be revised to include digital skills and AI competencies.
2. Provide training and capacity building for instructors/teachers: Instructors should be provided with training and capacity building opportunities by the concern authorities.
3. Foster and promote collaboration between industry and TVET institutions: Industry and TVET institutions should collaborate to develop curricula and provide work-based learning opportunities.
4. Ensure equity and access: Efforts should be made by the Nigerian government to ensure that all students have access to digital skills and AI training, regardless of their background or location.
5. Governmentshould invest in infrastructure and resources development.

References

Adadi, A., &Berrada, M. (2018).Peeking Inside the Black-Box: *A Survey on Explainable Artificial Intelligence* (XAI). IEEE Access, 6, 52138-52160.

Auty, R. M. (1993). Sustaining Development in Mineral Economies: *The Resource Curse Thesis.*

Bakhshi, H., Downing, J. M., Osborne, M. A., & Schneider, P. (2017). The Future of Skills: Employment in 2030. Pearson.

Castells, M. (2009).*Communication Power*.Oxford University Press.

Chauhan, A. (2018). 11 Digital Education Tools for Teachers and Students. From https://elearningindustry.com

Dixon, M., Klabjan, D., & Bang, J. H. (2020). Machine learning for finance: Principles and practice. *Journal of Financial Data Science*, 2(1), 1-14.

Esteva, A., Robicquet, A., Ramsundar, B., & Dean, J. (2019).A guide to deep learning in healthcare.*Nature Medicine*, 25(1), 24-29.

European Commission.(2020). Digital Skills in the EU Labour Market.

Falade, A.A. &Alimi, A.E. (2015).Emerging Technologies in Education. In Yusuf, M.O & Onasanya, A. (Ed.), Critical Issue in Educational Technology (pp.221-236). Ilorin, Kogi State, Nigeria: Department of Educational Technology, University of Ilorin.

Farias, M., & Rochester, S. (2019). Artificial Intelligence in Education: *A Review of the Literature.*

Frey, C. B., & Osborne, M. A. (2017). The future of employment: How susceptible are jobs to computerisation? *Technological Forecasting and Social Change,* 114, 254-280.

Ferrari, A. (2012). Digital competence in practice: An analysis of frameworks. Sevilla: JRC-IPTS. Available at: http:/ftp.jrc.es/EURdoc/JRC68116.pdf.

Himmelsbach, V. (2019), 6 Pros and Cons of Technology in Classroom in 2019. From https://tophat.com>blog>6-pros-cons-t....

International Labour Organization.(2019). World employment social outlook.

International Monitory Fund (2019).Diversifying Economies.

Jordan, M. I., & Mitchell, T. M. (2015). Machine learning: *Trends, perspectives, and prospects. Science,* 349(6245), 255-260.

Katz, L. F., & Krueger, A. B. (2016).*The Rise and Nature of Alternative Work Arrangements in the United States, 1995-2015*.Princeton University.

Kluwer, J. (2020). Bias in AI: A review of the current state of AI bias and potential solutions. *arXiv preprint arXiv*:2004.05966.

Kurzweil, R. (2005). The singularity is near: *When humans transcend biology.*Penguin.

Ma, X., Li, Y., &Ren, Y. (2019).A survey of deep learning-based object detection for autonomous driving.*IEEE Transactions on Intelligent Transportation Systems,* 20(4), 931-943.

Maseko, V. (2024). Overview of skill demand shifts over the decade. https://www.linkedin.com/pulse/emerging-trends-tvet-impact-ai-digitalization-dr-vusimaseko-phd--gmzqf.

Organisation for Economic Co-operation and Development.(2019). OECD skills outlook: *Thriving in a digital world.*

Organisation for Economic Co-operation and Development (2019).OECD Innovation Strategy.

Organisation for Economic Co-operation and Development(2020).Education and the Future of Work.

Porter, M. E. (1990). The Competitive Advantage of Nations.

Russell, S. J., &Norvig, P. (2010).*Artificial intelligence*: A modern approach. Prentice Hall.

Schumpeter, J. A. (1942). Capitalism, Socialism, and Democracy.

Ukala, C.C. &Iheukwumere, O.C. (2025) Integrating AI in TVET in Public Institutions InAbia State, Nigeria: Bridging Skills Gaps for Future Workforce. *International journal of scientific research in Education (IJSRE)*

United Nations Educational, Scientific and Cultural Organization (2019).TVET for Sustainable Development.

United Nations Educational, Scientific and Cultural Organization (2022) Digital skills development in TVET teacher training, UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training UN Campus Platz der VereintenNationen 1 53113 Bonn Germany

Van Deursen, A. J. A. M., & Van Dijk, J. A. G. M. (2014).*Digital Skills: Unlocking the Information Society*. Palgrave Macmillan.

World Bank. (2016). World Development Report: *Digital Dividends.*

World Bank. (2020). World Development Report: *Global Value Chains in a Post-COVID-19 World.*

World Economic Forum. (2020). The Future of Jobs Report.

WTO (2020).World Trade Report .

EXPLORING THE AVAILABILITY, ACCESSIBILITY, AND UTILIZATION OF COMPUTER AND INTERNET RESOURCES AMONG CHEMISTRY UNDERGRADUATE STUDENTS IN KANO STATE.

[1]KASIM IBRAHIM MOHAMMED
asim252000@yahoo.com
08036220304
[2] Dr. ABUBAKAR ZUBAIR YUSHAU
abubakaryushau88@gmail.com
08036190071
[3]SALISU MUHAMMAD ALIYU
baffasma@gmail.com
07037729095
&[4]ISHAQ MOHAMMED ALIYU
maishaq99fm@gmail.com
08034529520
Department of Chemistry,
Faculty of Science Education
Yusuf maitama sule
Federal University of Education, Kano

Abstract

This study investigated the Availability and accessibility of computer and internet resources among chemistry undergraduate students in Kano state and their influence on academic achievement. The study employed a descriptive survey design, and a sample of 322 undergraduate chemistry students was selected using a proportionate stratified random sampling technique from four government-owned universities in Kano state, comprising 198 males and 124 females. The research instrument used was the Chemistry Undergraduates Attitude towards Computer and Internet Resources Questionnaire (CUATCIRQ), which consisted of four sub-scales. The instrument was validated by and the reliability coefficients of the two sub-scales were 0.82, and 0.73 for attitude and usability respectively using Split Half method, Cronbach Alpha was used to calculate the reliability index, for internal consistency. To measure academic achievement, students' first semester examinations GPAs were used. Frequency count, percentages, means, and standard deviation were used to answer the research questions, while PPMC correlation was used to test the null hypotheses at the 0.05 level of significance using SPSS version 25. There was no significant relationship between availability and utilization of computer and internet resources among undergraduate chemistry student in the universities. Based on the study's findings, it is recommended that federal and state ministries of education should provide adequate provisions for computers, internet facilities, and overhead projectors, as well as a regular supply of electricity in schools. This will enhance attitudes towards the use of computer system and also internet resources and improve the academic achievement of undergraduate chemistry students.
Keywords: *Availability, Accessibility, Chemistry, Computer, Internet Recourses,*

Introduction

Science comprises of the basic disciplines which include; Chemistry, Physics and Biology. Chemistry which is of interest to the current study is a science subject that occupies a prominent place in the school science curriculum. Lumen (2019) defined chemistry as the

study of matter and the chemical reactions between substances, while Rice University (2019), defined chemistry as the study of composition, properties, and interaction of matter. Chemistry is sometimes referred to as "the central science" due to its interconnectedness with a vast array of other science, technology, engineering and mathematics (STEM) disciplines (Theodore & Le May, 2014). The fields of chemistry and the terminology used by chemists have far-reaching impacts across numerous domains of science and research. Chemistry provides fundamental understanding and tools that are core to advancing disciplines like biology, medicine, materials science, forensics, and environmental science (Mater, & Coote, 2019). Chemistry relies on and informs allied fields through shared principles. Physics concepts underpin chemistry comprehension. Mathematics, computing, and information theory supply tools to quantify, analyze, model, and simulate reactions. Biology and chemistry converge in biochemistry, applying chemical insights to elucidate life's molecular mechanisms. Cross-disciplinary integration with physics, mathematics, computing, and biology advances chemistry and biochemistry understanding (Mazzocchi, 2019).

The importance of chemistry in the development of any nation cannot be underrated. According to (Helmenstine, 2019), the overall importance of chemistry is that it explains the world around us. There are several areas that chemistry is found to be very important; preservation of food, nutrition, production of cleaning agents such as soap and detergent, in developing new medical treatment and medicines, in environmental issues to help man know how to clean up the environment and provide knowledge of things that could be harmful to the environment and so on. Also, for all living things to function and survived their bodies perform various chemical processes. Some of those processes include; respiration, digestion, producing new cell, filtering and releasing of waste substances from their bodies, reproduction, etc. so all living things depend on chemical reactions to function and survived (Adejoh & Tse, 2016). Chemistry is needed for the continual advancement of technology (Tolu, 2019). By using the principles of chemistry, we are able to extract different types of metals and also create different types of plastics. Plastics and metals pervade all sectors of society and industry. They are utilized to build the infrastructure of offices, housing, transportation like cars and trains, power systems, and manufacturing facilities. Metals and plastics also comprise electronic devices, from phones and tablets to medical and laboratory equipment. The food industry additionally incorporates these materials (Brandt, Salerno, & Fuchter, 2017).

Computer and internet resources are the main components of information and communication technology (ICT) (Inyang & Effiong, 2016). According to Barineme (2014), computer is an electronic device that accepts data as input, process the data in the processing unit saves the processed data as RAM or ROM or give out result of the processed data as information through an output device like screen or printer. While, internet can be defined as a global system of networked computers that allow user-to-user communication and transfer of data files from one machine to any other on the network (Ikediugwu, 2015). The role of these computer and internet resources facilities such as computer and the internet enables the teacher to deliver his/her lecture in such a way as to achieve the stated specific objectives of the lesson, such as the cognitive, affective and psychomotor domains without findings it difficult (Fashina & Akanji, 2016). The introduction of computers in all levels of education in Nigeria helps tutors impact programmed knowledge to their students (Inyang & Effiong, 2016). Additionally, the availability of high speed internet in the 21st century has pushed learning beyond the confines of physical classrooms. For instance, a student at home can participate in regular classes using interactive technology. E-learning has become a common place as modern education is no longer restricted to sitting in a classroom and taking notes. As

a matter of fact, students are empowered to draw on the richness of the internet to research any subject matter ranging from historical events to stimulations of challenging chemistry problems (Olorukooba & Kazeem, 2016).

However, researchers in Nigeria have shown that these computer and internet resources facilities and internet are not available, where available they are not fully utilized (Asiyai, 2014, Apuke & Iyendo, 2018; Eze, Chinedu-Eze, & Bello, 2018). Others have shown some teachers are not competent (Okoro, & Bassey, 2018; Ikwuka, *et al.*, 2021). Lack of use of computer and internet resources have been attributed to the attitude the usage of the computer and internet resources facilities and internet (Kyalo & Nzuki, 2014).

Statement of Problem

The Federal government of Nigeria recognizes the need for computer and internet resources in education in her various policies (Federal Republic of Nigeria, 2013). However, the state of infrastructure on ground is not commensurate to the media attention generated and therefore the availability, adequacy, accessibility and usability of computer and internet resources have been issues of research (Olatokun, 2017).

The rapid advancement of technology has transformed the education sector, making access to computer and internet resources essential for academic success. In chemistry education, these resources play a crucial role in facilitating research, virtual simulations, online learning, and collaboration among students and educators. However, in many developing regions, including Kano state, the availability and accessibility of these recourse remain a significant challenge

Many chemistry undergraduate students in Kano state may lack. Adequate access to computers and reliable services due to factors such as insufficient infrastructure, high coasts, and limited institutional support. This limitation could hinder their ability to conduct research, complete assignments, engage in online learning, and develop digital literacy skills necessary for academic excellence. Additionally, disparities in access to these resources may create an academic divide, where students with better access perform significantly better than those without.

Giving the increasing reliance on digital tools for education, it is important to assess the availability and accessibility of computer and internet resources among chemistry undergraduate students in Kano state and determine their impact on academic achievement. Understanding these challenges can help policymakers, educators, and institutions develop strategies to improve digital access and enhance students' learning experiences.

Objectives of the Study

This study sought to:

i. **To assess the availability** of computer and internet resources for chemistry undergraduate students in Kano state.
ii. **To examine the level of accessibility** of these resources among the students.

Research Questions

3. What is the level of availability of computer and internet resources for chemistry undergraduate students in Kano state?
4. How accessible are these resources to chemistry undergraduate students?

Hypotheses

HO_1: There is no significant relationship between the availability and utilization of computer & internet resources among undergraduate chemistry students in the universities.

Methodology

The study employed a descriptive survey design, and a sample of 322 undergraduate chemistry students was selected from the total population of 1711recommended by research advisors 2006, using a proportionate stratified random sampling technique from four government-owned universities in Kano state, comprising 198 males and 124 females. The research instrument used was the Chemistry Undergraduates Attitude towards Computer and Internet Resources Questionnaire (CUATCIRQ), which consisted of four sub-scales. The instrument was validated by expert in chemistry education and psyclogy. The reliability coefficients of the four sub-scales were 0.84, 0.79, 0.82, and 0.73 for items on availability, accessibility, utilization, and attitudes towards the use of computer and internet resources, respectively. This indicates that the questionnaire subscales were all reliable, using Split Half method Cronbach Alpha was used to calculate the reliability index, for internal consistency. To measure academic achievement, students' first semester examinations GPAs were used. Means, and standard deviation, Pearson product-moment correlation and point biserial were used to answer the research questions, while Point biserial and Pearson product-moment correlation were used to test the null hypotheses at the 0.05 level of significance using SPSS version 25.

Result

Research Question 1: What is the level of availability of computer and internet resources for chemistry undergraduate students in Kano state?

According to the Benchmark minimum Academic Standard for undergraduate programs sin Nigerian Universities (BMAS), which states that computer and internet resources should be available for at least 25% of the total students enrolled in each academic program, more 90% of the computer and internet resources listed in Table 1 are available. These resources include computers, spreadsheets like Microsoft Excel, presentation software such as PowerPoint, graphic software like Chem Draw and Chem Sketch for drawing chemical structures, projectors, internet access, and storage devices like flash drives, CDs, DVDs, and more

Table 1: Summary of availability of computer & internet resources in each university

S/N	Resources	BUK			YUMSUK			KUST			POLAC		
		No. Available	No. recommended by NUC	Decision	No. Available	No. recommended by NUC	Decision	No. Available	No. recommended by NUC	Decision	No. Available	No. recommended by NUC	Decision
1.	Computer	350	132	Adequate	300	128	Adequate	450	143	Adequate	100	32	Adequate
2.	Spread Sheet such as Ms. Excel	350	132	Adequate	300	128	Adequate	450	143	Adequate	100	32	Adequate

3.	Power point package for presentation	350	132	Adequate	300	128	Adequate	450	143	Adequate	100	32	Adequate
4.	Graphic software such as ChemDraw&ChemSketch for drawing chemical structures	0	Not specified	Not Availabl e	0	Not specifie d	Not Availab le	0	Not specifie d	Not Availab le	0	Not specif ied	Not Available
5.	Projector	15	Not specified	Adequate	12	Not specifie d	Adequate	20	Not specifie d	Adequate	10	Not specif ied	Adequate
6.	Storage devices such as flash, CD, DVD, e.t.c.	67	Not specified	Adequate	50	Not specifie d	Adequate	65	Not specifie d	Adequate	48	Not specif ied	Adequate
7.	Search Engines	350	132	Adequate	300	128	Adequate	450	143	Adequate	100	32	Adequate
8.	Internet	350	132	Adequate	300	128	Adequate	450	143	Adequate	100	32	Adequate
9.	Encyclopedia	50	Not specified	Adequate	35	Not specifie d	Adequate	70	Not specifie d	Adequate	30	Not specif ied	Adequate
10.	E-Journals	250	Not specified	Adequate	150	Not specifie d	Adequate	200	Not specifie d	Adequate	87	Not specif ied	Adequate

BUK- Bayero University Kano, **YUMSUK**-Yusuf Maitama Sule University Kano, **Kano, KUST**-Kano University of Science and Technology **,** **POLAC**-Nigeria Police Academy ,Wudil

Research question 2: How accessible are these resources to chemistry undergraduate students?

Table 2:Frequency and percentages of accessibility of computer & internet resources

S/N	Resources	Accessible Frequency	%	Not Accessible Frequency	%	Remarks
1.	Computer	232	72.0	90	28.0	Accessible
2.	Spread Sheet such as Ms. Excel	316	98.1	6	1.9	Accessible
3.	Power point package for presentation	221	68.6	101	31.4	Accessible
4.	Graphic software such as Chem Draw & Chem Sketch for drawing chemical structures	193	59.9	129	40.1	Accessible
5.	Projector	230	71.4	92	28.6	Accessible
6.	Storage devices such as flash, CD, DVD, e.t.c.	212	65.8	109	33.9	Accessible
7.	Search Engines	209	64.9	113	35.1	Accessible
8.	Internet	191	59.3	131	40.7	Accessible
9	Encyclopedia	214	66.5	108	33.5	Accessible
10.	E-Journals	199	61.8	123	38.2	Accessible

The descriptive statistics in Table2 indicated that the students have access to all the items as indicated by their high percentage of positive response which is greater than 50% which the researcher considered the least percentage of acceptances to the accessibility of the items.

HO_1: There is no significant relationship between the availability and utilization of computer & internet resources among undergraduate chemistry students in the universities.

Table 3: Frequency of the use of computer and internet resources for studying chemistry

S/N	Resources	Daily		Twice a week		Once a week		Occasionally		Mean	SD	Remark
		Freq.	%	Freq.	%	Freq.	%	Freq.	%			
1.	Computer for processing document	26	8.1	30	9.3	68	21.1	198	61.5	1.81	1.10	**Occasionally**
2.	E-mail for sending and receiving mails	31	9.6	44	13.7	54	16.8	193	59.9	2.45	1.03	**Twice a week**
3.	Internet for assignment, downloading materials and communication, e.t.c	52	16.1	54	16.8	69	21.4	147	45.7	2.35	1.16	**Twice a week**
4.	Spread sheet such Ms. Excel	38	11.8	38	11.8	39	12.1	207	64.3	1.09	1.01	**Occasionally**
5.	Power point package for presentation	33	10.2	36	11.2	30	9.3	222	68.9	1.74	1.07	**Occasionally**
6.	Graphic software such as Chem Sketch for drawing chemical structures	41	12.7	39	12.1	20	6.2	222	68.9	1.69	1.06	**Occasionally**
7.	Scanner	32	9.9	37	11.5	54	16.8	199	61.8	1.74	1.21	**Occasionally**
8.	Smartphone	133	41.3	97	30.1	53	16.5	39	12.0	3.15	1.02	**Daily**
9	Projector	29	9	46	14.3	64	19.9	183	56.8	1.59	1.04	**Occasionally**
10.	Storage devices such as flash, CD, DVD, e.t.c.	22	6.8	45	14.0	71	22	184	57.1	1.66	1.13	**Occasionally**

The results from Table 3 suggest that undergraduate chemistry students in universities in Kano State use the internet, email, and their smart phone more frequently than other surveyed resources. The mean values for these items are close to the criterion mean of 2.5, indicating that they are important resources for these students. Additionally, the smartphone appears to be the most frequently used resource among the surveyed resources. Whereas, majority of the response indicated that the computer and internet resources are occasionally use as shown by mean values below the criterion mean of 2.5.

Table 4: PPMCC analysis of the availability and utilization of computer & internet resources among undergraduate students in the universities

Variables	***N***	***Mean***	***SD***	***Df***	***R***	**p**	**Remark**
Availability rating	322	11.06	2.41	320	-0.09	0.12	Not significant
Utilization rating		28.59	6.79				

The result of the PPMCC analysis between availability and utilization of computer and internet resources from table 4.8 revealed that the relationship was negative, weak in strength

and not significant statistically(r=320=-0.09, p=0.12).Since the p-value is greater that the alpha value set for this null hypothesis($p \leq 0.05$).Therefore, the null hypothesis that there is no significant relationship between students' availability and utilization of computer & internet resources is hereby retained.

Discussion

This study investigated availability and accessibility among undergraduate chemistry students in Kano State, and its influence on their academic achievement. Two research questions were answered and one null hypothesis was tested based on the respondents' responses to the questionnaire. The analysis of data obtained was presented in Tables 1 to 4 in accordance to research questions and the null hypotheses. The findings of from the analysis are discussed as follows:

The finding of this study showed that computer and internet resources are available in the universities in Kano. The availability of computer and internet resources in these universities has shown that the schools are cognizant of the importance of these information and communication technology in enhancing teaching and learning. This finding is in agreement with Armstrong (2016), Castro Sanchez & Aleman (2015) have reiterated that computer and internet resources tend to expand access to education as well as assist in transforming the teaching environment to a learner centered one. This could account for why these universities are ensuring that they make available computer and internet resources that may help engage the students and make access to learning material relative easy. However, this finding is at variance with Nwana, ofeogbu & Egbe (2017) who found out in their study that that majority of the computer and internet resources needed for the teaching of computer education in Anambra state are not available.

The findings also indicated that the available computer and internet resources are accessible to the undergraduate chemistry students for use. This implies that access to the available computer and internet resources is easy and also affordable. It then means that the ease of getting these resources when put to use can make students and lecturers to be more active and productive in the classroom. However, this finding is in disagreement with the finding of Thankgod & Vulasi (2020) that revealed that ICT facilities are not accessible in secondary schools in Rivers State.

The finding of this study also revealed that the computer and internet resources available are occasionally used by undergraduate chemistry students except for smart phones that are utilized most of the times. This may be as a result of the fact that some of students are not computer literate and so do not have confidence in the use of the various computer and internet resources. This is in line with, Fredrick (2014) Who attributed the occasional used of computer and internet resources to the fact that many universities and institutions of higher learning in the country now can boast of computer and internet resources centers, yet the fact remains that some of these computer and internet resources centers are not functional as a result of many obstacles such as what mention them. The findings collaborated with the finding of Fančovičová & Prokop (2018) who attributed the occasional use of computers by students to large number of students compare to the available ones. It was also revealed that the use of the smart phones is a bit more frequent than other resources, this could be as a result of the availability of these resources all round the campus and most of the students have their internet-enable phones with them that they may use to check their emails and browse chemistry assignment.

Conclusion

Based on the findings from this study, the following conclusions are drawn:.

4. Computer and internet resources are available in the universities in Kano State.
5. Undergraduate students in the universities in Kano State have access to the available computer and internet resources.
6. The computer and internet resources available are occasionally used except for smart phones that are utilized most of the times. Also, there is no significant relationship between the availability and utilization of computer and internet resources among undergraduate chemistry students in the public universities in Kano state.

Recommendations

Based on these findings, the following recommendations are made:

1. Universities in Kano State should improve the utilization of computer and internet resources among undergraduate chemistry students through awareness campaigns and training programs.
2. Universities should consider implementing policies that require students to regularly utilize computer and internet resources for academic purposes such as e-teaching and e-learning
3. Further research should be conducted to investigate the impact of other factors, such as socioeconomic status and prior experience, on students' attitudes towards the use of computer and internet resources.
4. It is recommended that universities in Kano State should invest in the provision of adequate computer and internet resources to enhance their usage among students.

References

Adejoh, M.J. & Tse, T. R (2016).The impact of social networks on students' academic achievement in Biology in Benue state. *Proceedings of the 57th Annual Conference of the Science Teacher Association of Nigeria*. HEBN Plc. Ibadan.

Armstrong, O. (2016). Variety of role for a new type of teacher. Educational technology and the teacher profession. *Teacher and Teacher Education,21*(4),15-31.

Apuke, O. D. & Iyang, T. O. (2018). University students' usage of the internet resources for research and learning: forms of access and perceptions of utility. **Heliyon,**4(12), e01052.

Asiyai, E. (2014). A survey of cyber cafes in Delta State. Nigeria. The Electronic Library 21 (5),487-495.

Barineme, K, M. (2014).*Curriculum Innovation*. Retrieve from http://www.babson.com /344/compter-an-electronic-device-for-data -processing/

Castro, Y.S, Sanchezs, E.V. & Aleman, G. (2015). Computer attitude and use among novice teachers: The moderating effects of school environment. *Malaysian Journal of Learning and Instruction,7*(3),93-112.

Eze, S. C., Chinedu-Eze, V. C., & Bello, A. O. (2018). The utilization of e-learning facilities in the Educational delivery system of Nigeria: a study of M-university. *International Journal of Educational Technology in Higher Education.* 15, Article 34.

Fančovičová, J., &Prokop, P. (2018). Students' attitudes toward computer use in Slovakia. *Eurasia Journal of Mathematics, Science and Technology Education, 4*(3), 255-262.

Fashina, O. & Akanji, F. (2016).Information and Communication Technology and students' cognitive development: A case study of English and History students, Adeyemi College of Education, Ondo, Nigeria. *Journal of Qualitative Education. 12*(9),45-52.

Federal Republic of Nigeria(2017).*National Policy on Education*. Lagos: NDERC Press.

Fredrick, E (2014).*Transformation of medieval natural philosophy from the early period modern period to the end of the nineteenth century. A History of Natural Philosophy: From the Ancient World to the Nineteenth Century (First ed.)*. New York, New York: Cambridge University Press. pp. 2

Helmenstine, A. (2019). *what is the importance of Chemistry*. Retrieved from Thought Co: https://www.thoughtco.com/what-is-the-improtance-of-chemistry-604143

Ikediugwu, Y. W. (2015). Managing information and communication technology in the classroom. *Nigeria Journal of Curriculum studies,14*(1),56-63.

Ikwuka, E. V., & Samuel, P. E. (2017). Effect of cooperative learning strategy on senior secondary school students' achievement and interest in chemistry in Nsukka educational zone. *Journal of Education and Practice, 8*(22), 113-121.

Ikwuka, T.C. (2020). Information Technology in environmental education discipline in Nigeria: Need for Improvement. *Journal of Computer*

Ikwuka, O. I., Akudolu, P. L. I., Ejikeme, R. N., Olugbemi, P. O., & Okoye, A. C. (2021). Effect of Role-Playing on students' Academic Achievement in Government secondary schools in Akwa Education Zone, Nigeria. *Himalayan Journal of Education and Literature*, 2(1)

Inyang, U.E. & Effiong, W.E. (2016).*The students view of information and communication technology in education at the university level: skill, attitudes and expectations.* Retrieved from www.homepage.ed.ac.uk/jhaywood/papersstudentsviewpdf

Kyalo, D. M., & Nzuki, D. M. (2014). Factors influencing the use of ICT resources in teaching and learning in secondary schools in Mwingi Central Sub-County, Kitui County, Kenya. *International Journal of Education and Research, 2(4), 397-406.*

Lumen G. (2019, February 1). *Overview of Chemistry*. Retrieved from https://courses .lumenlearning.com/boundless-chemistry/chapter/overview-of-chemistry/

Mater, A. C., & Coote, M. L. (2019). Deep Learning in Chemistry. *Journal of Chemical Information and Modeling.* 59(6), 2545-2559,

Mazzochi, C. J. (2019). On Randomness SCIREA. *Journal of Mthematics,* 4(6)

Nwana, S., Ofoegbu, T., &Egbe, C. (2017). Availability and utilization of ICT resources in teaching computer education in secondary schools in Anambra State, Nigeria. *Mediterranean Journal Of Social Sciences, 8*(5), 111. Retrieved from https://www.mcser.org/journal/index.php/mjss/article/view/10065

Okoro, S. N., & Bassey, U. E. (2018). N-Power teachers competence and resources utilization Implication for effective and efficient teaching in Nigerian Primary and Post-Primary schools. *International Journal of Education and Evaluation.* 4(1), 12-21.

Olatokun, W. M. (2017). Availability, accessibility and use of Computer and internet resources by Nigerian women academics. *Malaysian Journal of Library & Information Science, 12*(2), 13-33.

Olorukooba, S. B., Sani, S., & Kazeem, S. (2016). The impact of computer simulations on performance and retention of students in qualitative analysis at senior secondary schools in Zaria, Kaduna state. *Journal of Science, Technology and Education, 4*(2), 169- 178.

Rice University. (2019, March 23). *Chemistry*. Retrieved from Rice University: https://chemistry.rice.edu/

Rojweski, G.O.(2014) The effect of information literacy on the utilization of electronic information and resources in selected academic and research institutions in Uganda. *The Electronic Library 25*(3),328-341.

Roschelle, J., Shechtman, N., Tatar, D., Knudsen, J., & Kaput, J. (2020). Integrating technology, curriculum, and professional development for advancing middle school mathematics: Three large-scale studies. *American Educational Research Journal, 47*(4), 833-878

Runi, J. (2014).*Information and communication technology and learning theories: preparing pre-service teachers For the classroom.* Retrieved from www.leads.ac.uk/./oooo2496.htmon3/9/15.

Thankgod, J. N., &Vulasi, B. K. (2020). Utilization of ICT in the administration of public senior secondary schools in Rivers State. *International Journal of Research and Scientific Innovation 2*(2), 401-413.

Theodore, L.B. &LeMay, H.E(2014). Chemistry: The Central Science. Prentice Hall.

Tolu, O.T. (2019). Science and Technological Adnacement:The Role of Chemistry. Ibadan: Sunshine Press.

SUB-THEME 10
BUSINESS TECHNOLOGY

EXPLORING THE INTEGRATION OF DIGITAL SKILLS AND ARTIFICIAL INTELLIGENCE (AI) IN BUSINESS EDUCATION: IMPLICATIONS FOR 21 CENTURY

Inalegwu.O. Mary
E-mail: ojogbane2015@gmail.com
Department: Business Education, School of Secondary Education (08037865040)
Federal University of Education, Kano.

Abstract

The rapid evolution of digital technologies is fundamentally transforming global business landscapes. This paper explores the integration of digital skills and AI in business education and examines the implications for students, educators, institutions, and the broader economy in the 21st century. The paper examines the current state of digital skills integration and AI adoption in business education, identifying best practices, challenges, and future directions. The paper further unearthed the challenges of Artificial Intelligence in Business Education to include lack of artificial intelligence literacy, curriculum development, access to artificial intelligence resources, ethical consideration, data quality and availability, regulatory and legal consideration among others. The identified challenges of artificial intelligence in business education include limited access to AI resource infrastructure, high cost of AI power tools, lack of digital literacy, ethical and private concerns, navigating regulatory/legal framework for AI in business education resistance to change among others. Thus, the paper recommends some possible solutions to the challenges of AI in Business Education to include, Professional development and Training, invest in infrastructure update of curriculum, promote a culture of innovation, ensure inclusivity amongst others, while the proffering solutions to challenges of AI in business education include, Investment in Technology Ethics and Responsible AI Education: Faculty development, Balance AI with human skills, etc. The paper provides recommendations for business educators, policymakers and industry stakeholders to leverage digital skills and AI in business education, fostering a competitive and innovative workforce for the 21st century.
Keywords: Digital Skills. Artificial intelligence. Business education · (AI) 21st Century

Introduction

The world is amid a transformational change. The changes are rapid- economic, social and technological transformations. These transformations, and particularly the impact of the fourth industrial revolution driven by digital technologies, have increased demand for higher-order skills, competencies and knowledge. Today's modern learner is a complex, energetic and technology driven individual that needs to be challenged and inspired by his learning. He needs to be his own boss, collaborate and incorporate technology which he loves into classroom experiences as well as work with peers. It is increasingly clear that theoretical understanding alone is not enough to prepare students for lifelong learning to thrive in the world of work. With increasing global competitiveness and emerging trends, learners' curiosities are spurred towards being independent and self-reliant. The 21st Century world is moving at a speed beyond imagination. From technology, to business, the health sector to military organization, everything is getting updated with the emergence of technologies. To this end, there is need for a functional and lifelong education for the acquisition of appropriate skills and the development of mental, physical, as well as social abilities and competencies to equip the learner to live in and contribute to the development of society.

The 21st century has ushered in a new era of digital transformation, with technology. like AI, big data, cloud computing, and blockchain redefining how businesses operate. The progress of technology has revolutionized many areas, including education. Artificial Intelligence (AI) is one of the most significant discoveries rapid in recent years, having transformed teaching and learning processes across numerous disciplines. The concept of Artificial Intelligence (AI) has been around for decades, but its application in education is a relatively recent development. AI in education refers to the use of AI technologies to enhance teaching and learning. This can include anything from AI-powered tutoring systems to AI-driven tools that help educators simplify tasks. While AI is still in its early stages of development, it has the potential to revolutionize the way students learn, and lecturers teach.

21st Century skills are essential for individuals to thrive in the modern workplace, and they are becoming increasingly important as technology, particularly AI, continues to advance. AI impacts on the types of skills that are most valued in the 21st century as it automates routine tasks, there is increasing demand for skills such as critical thinking, problem-solving, creativity, emotional intelligence and adaptability (United Nation, 2021).
Business education as a branch of vocational education equips its recipients with relevant skills needed in the world of work. According to Ezenwafor and Onokpaunu (2017), business education programme is a branch of vocational education concerned with exposing its recipients to the internal and external foundations and functioning of the workplace. Business education is a work-focused, skill-based, result-oriented and technology-based educational programme (Ugwoke, 2011). With the knowledge of business education, students are better informed and groomed with skills and understanding to cope with the unpredictable challenges of the business environment. However, the business education programme which is charged with the responsibility of unveiling the dynamics of the world of work must ensure that its recipients possess the relevant skills needed for effective entry and efficient participation in economic development. Oguejiofor (2020) in support of the above stated that the value of any business education programme could be determined by its ability to adequately prepare and equip individuals in such a manner that they could fit into specific jobs, become technologically relevant, internationally competitive and economically prosperous, if properly packaged and adequately delivered. However, the reliable medium through which the mission and vision of business education programmes can be achieved, stems from effective review and implementation of its curriculum (Ezenwafor & Onokpaunu, 2017). Curriculum is the means through which laid down educational philosophy of a nation is translated into concrete reality. It contains prescribed courses of studies which students must learn to reach a certain level of education. Okoro (2015) opined that business education curriculum entails educational training which an individual receives to acquire adequate attitudes, concepts, knowledge, understanding and skills in business activities for vocational use in careers as administrators, managers, teachers wherever he may find oneself in the business world. It is believed that the curriculum of business education exposes students to educational and business-related experiences. However, Oguejiofor (2020) reported that curriculum offerings at the tertiary institution levels do not cater for some of the needs of the current century skills. In agreement, Ikpesu (2017) stated that business education in Nigeria is at variance with global digital world. This variance, however, portrays a total disconnection between what higher education offers and the needs of the labour market. The challenge here lies in how to ensure that the curriculum and delivery system provide satisfactory output that can compete globally in the labour market. To achieve this, there is need for the integration of digital skills in the teaching of business education programme. According to UNESCO (2018), digital skills are a range of abilities to use digital devices, communication

applications, and networks to access and manage information. They enable people to create and share digital content, communicate and collaborate, and solve problems for effective and creative self-fulfillment in life, learning, work and social activities at large. Ferrari (2013) saw digital skills as the ability to critically analyze and assess digital information, problem solving using digital tools, creation and recreation of content and so forth. The International Telecommunication Union (ITU) (2018) defined digital skills as a set of technological abilities that may be fully or partially acquired before entering the world of work. In the context of this study, digital skills are the abilities of using digital technologies to transform existing traditional and non-digital business processes and services, or creating new ones, to meet evolving market and customer expectations. ITU (2018) categorized these skills as: basic digital skills, intermediate digital skills and advanced digital skills. Basic digital skills are the fundamental skills needed to use digital technologies, such as using a browser, connecting to the internet, and keeping passwords secure. The skills are required for effective use of ICT tools, systems and devices to support task/functions. Basic digital skills foster competency in interaction with basic digital tools. Basic skills level cover hardware and software know-how required to use various technological assets such as computers, smartphones, software (word processors, applications), online operations (Internet, search engines, social networks, e- commerce, privacy) and communication media (Laar, Dijka, & Haan, 2020).

Concept of Digital Skills

In the contemporary educational environment, the integration of digital technologies is seen as essential for preparing students to thrive in the digital world. Digital skills are a set of technological abilities used to access and manage digital information. According to UNESCO (2018), digital skills are a range of abilities to use digital devices, communication applications, and networks to access and manage information. They enable people to create and share digital content, communicate and collaborate, and solve problems for effective and creative self-fulfillment in life, learning, work and social activities at large. Ferrari (2013) saw digital skills as the ability to critically analyze and assess digital information, problem solving using digital tools, creation and recreation of content and so forth. The International Telecommunication Union (ITU) (2018) defined digital skills as a set of technological abilities that may be fully or partially acquired before entering the world of work. In the context of this study, digital skills are the abilities of using digital technologies to transform existing traditional and non-digital business processes and services, or creating new ones, to meet evolving market and customer expectations. Some digital skills are required to use and interact with technology to fulfil specific tasks, while others are required to design, create and maintain tools and solutions for different industries. ITU (2018) categorized these skills as: basic digital skills, intermediate digital skills and advanced digital skills. Basic digital skills are the fundamental skills needed to use digital technologies, such as using a browser, connecting to the internet, and keeping passwords secure. The skills are required for effective use of ICT tools, systems and devices to support task/functions. Basic digital skills foster competency in interaction with basic digital tools. Basic skills level covers the hardware and software know-how required to use various technological assets such as computers, smartphones, software (word processors, applications), online operations (Internet, earch engines, social networks, e- commerce, privacy) and communication media (Laar, Dijka& Haan, 2020).

Integration of Digital Skills in Business Education Digital skills encompasses a range of competencies, including data literacy, digital communication, cybersecurity, and the use of business software. Effective integration requires curriculum redesign, investment in faculty

training, and the incorporation of experiential learning platforms. Examples from top-tier institutions showcase innovative pedagogies such as flipped classrooms, virtual simulations, and digital labs. Tripathy (2019) also noted that digital skills required in this new digital economy must be taught to the students to minimize the risk of digital skills gap. However, Okolocha and Ile (2012) posited that comprehensive and systematic transformation of business education programme must occur to address the challenges of preparing well qualified individuals for the development of the nation. Business educators should therefore equip themselves with new technological skills needed to train students to meet the demands of the modern business world. Integration of digital skills in business education will adequately equip business education graduates with relevant ICT skills needed to establish and manage their personal business enterprises more profitably for the development of required digital economy.

Concept of Artificial Intelligence (AI)

Artificial intelligence (AI) is human intelligence or behaviour demonstrated by machines, an innovative technical framework that encompasses the creation of computer systems with the ability to execute activities that usually need human intellect (Aina *et al.*, 2023), in practice, AI is a computer programme-software (IDRA, 2018). Areas in which AI can transform teaching and learning include, but are not limited to personalized learning, adaptive learning, special needs education, bilingual education, gamification, ideation, virtual tutor and immersive learning. According to (Afongughe *et al.,* (2021); Aina, *et al.,* (2023); Chatterjee et al (2022) other usefulness of AI technologies include: Artificial Intelligent (AI) refers to the development of computer system that can perform tasks that typically require human intelligence; and the system can learn from data experiences and interactions, enabling them to improve their performance and adapt to new situations. It can also draw conclusions, make decisions and solve problems using logic, rules and patterns. Artificial Intelligence systems can identify and resolve problems often using creative and innovative approaches. The system can interpret and understand data from sensors, images, speech and text, enabling them to understand the world around them. According to Berglund, Bousfiha and Mansoori (2020), artificial intelligence system can also comprehend and generate human language, enabling them to communicate with humans; it is an Artificial Intelligence system that uses algorithms to process data, learn from experiences and the system rely on high-quality data to learn, improve and make accurate decisions.

According to (Afongughe *et al.,* (2021); Aina, *et al.,* (2023); Chatterjee et al (2022) other usefulness of AI technologies include: Personalized /Adaptive Platforms: This creates educational content based on individual students' performance and learning style example Knew ton. It also creates personalized mathematics lessons tailored to each student's level and learning pace, example Dream box. AI is used to adapt to learners' proficiency in language learning, example Duolingo, as well as personalizing study materials and quizzes based on the learners' learning ability and memory retention. Content creation tools: through software, AI helps learners to generate ideas, writing, designing and creating content such as marketing, social media, blogging, generating headlines, writing articles, designing graphics and producing videos. Virtual assistants like google assistant help with homework, answer questions, assist educational tasks. Smartboard provides real feedback interactive lessons, Chatbots answers questions, offer suggestions, guide users through learning materials. Using ChatGPT device can translate passages quickly and with little need for correction (IDRA, 2023).

Concept of Business Education

Business education as a branch of vocational education equips its recipients with relevant skills needed in the world of work. According to Ezenwafor and Onokpaunu (2017), business education programme is a branch of vocational education concerned with exposing its recipients to the internal and external foundations and functioning of the workplace. Business education is a work-focused, skill-based, result-oriented and technology-based educational programme (Ugwoke, 2011). With the knowledge of business education, students are better informed and groomed with skills and understanding to cope with the unpredictable challenges of the business environment. Business education is a study programme which aims at creating awareness for business occupation and preparing youths for work and people to become better citizens and intelligent consumers of goods and services (Gidado and Akaeze, 2014). It is an educational programme that provides its learners with competent skills to perform several tasks in the world of business and education comes in different specialties.

According to Edokpolor and Owenvbiugie (2017), business education is an essential element in vocational and general education that concerned with the impartation of business orientation and knowledge for personal and national development. Edokpolor and Owenvbiugie further affirm that business education involves teaching students the fundamental concepts, theories and processes of business. Business education in its dynamic nature and operation is designed to prepare young people for self-employment career and economic literacy in the marketplace (Amaewhule, 2017). According to Elujekwute, Nwaokwa, Aja & Oigoche, (2021), by understanding the concept of business education, students can be better prepared to succeed in the dynamic and complex business world. Business education is the type of education that assists individuals to acquire skills, which they can apply to solve problems in business and office occupations. Students are expected to have relevant skills and knowledge, an attitude to enable them to perform effectively in their private business and public offices.

Integration of Digital Skills and Artificial Intelligence in Business Education

Integrating AI and digital skills in business education helps students to develop knowledge and skills needed to pursue careers in technology, data science and other in-demand industries. It is also essential for developing digital literacy, critical thinking skills, personalized learning skills and preparing students for future academic and career success. According to Ibrahim, (2023), using AI can inspire students to generate ideas and solutions, fostering creativity and innovation, which are essential 21st century skills necessary in today's competitive and evolving job market through the following skills:

Digital skills and Artificial Intelligence can be integrated in business education through the following ways: Intelligence Tutoring System; an Intelligent Tutoring System (ITS) is a computer-based system that provides personalized guidance and feedback to students, mimicking the role of human tutors. It aims to adapt to individual learning needs, offering tailored support and instruction. Assessing students' knowledge, skills and learning style. Also, organizing and storing content expertise. It adapts to the individual pace and needs of the students. According to Tuomi (2018), intelligent tutoring offers effective and efficient learning experiences, making education more accessible and engaging and it supplements traditional teaching method and preparing students for standardized tests as well as providing tailored support for diverse learners.

Personalized Learning: Personalized learning is an educational approach that tailors learning experiences to individual students' needs abilities and learning styles. It aims to provide each student with a unique learning pathway, allowing them to learn at their own pace and focus on their strengths and weaknesses. It is centered thereby focuses on individual students' needs

and materials and allows students to learn at their own speed, adjust difficulty and content to match student progress, offers various routes to achieve learning goals. Regularly evaluates students' progress and adjusts instruction. Teachers guide and support students rather than lecturing. More so, artificial intelligence in business education helps to leverage digital tools and resources to enhance learning through technology integration.

Critical Thinking and Problem Solving: AI can create interactive simulations and scenarios that require students to analyze, evaluate and solve complex problems thus fostering critical thinking and problem-solving skills.

Collaborative and Communication: AI can facilitate collaboration among students by providing virtual environment for group work as well as enabling communication and feedback through ChatGPT, chatbots and virtual assistants.

Creativity and Innovation: AI tools can stimulate creativity by providing students with resources for generating new ideas, design solutions and experimenting with various forms of expressions, such as through creative writing or visual arts.

Information Literacy: AI can assist students in navigating and evaluating vast amounts of information, teaching them how to discern credible sources, validate information and think critically about the content they encounter.

Challenges of Digital Skills and Artificial Intelligence Integration in Business Education in the 21st century

One of the most pressing challenges in the integration of digital skills is the technical and infrastructural limitations that many institutions face**.** Integrating digital skills and Artificial *I*ntelligence (AI) into business in the 21st century offers immense potential but also brings a set of complex challenges. Acknowledging and addressing these challenges is paramount if we are to harness the potential of artificial intelligence to enhance entrepreneurship practice and foster a more innovative and resilient entrepreneurship ecosystem. The challenges are briefly discussed below

- Access to Technology and Infrastructure: Resource Disparity, not all institutions can afford cutting-edge technology, software licenses or AI lab. The high cost of AI power tools and platforms is a significant challenge in integrating Artificial Intelligence (AI) into business education this is because artificial intelligence software, platforms and tools such as machine learning frameworks, natural language processing libraries and predictive analytics software can be expensive to purchase or subscribe to it since requires vast amounts of data, which can be expensive to acquire, store and manage.
- **Lack of Literacy in Artificial Intelligence:** Lack of literacy in Artificial Intelligence (AI) is a significant challenge in integrating AI into business education. This is because the institutions may lack technical expertise to understand artificial concepts, tools, and applications, making it difficult to implement AI solutions. The inability to collect, analyze and interpret data effectively hinders artificial intelligence adoption of data as the foundation of AI application.
- **Curriculum Relevance and adaptability:** The need for continuous updating of the curriculum is a significant challenge in integrating Artificial Intelligence (AI) into business education. Artificial intelligence technologies and techniques are constantly evolving, requiring business educators and students to stay updated on the latest

development. AI and digital tools evolve quickly, making it hard for business schools to keep curricula up to date.

- **Ethical and Critical Thinking Gaps:** The ethical and Critical thinking gaps are significant challenges in integrating artificial intelligence into business education. Over-reliance on technology is a risk for students learning to use AI tools without understanding the broader implications. Also lack of ethical training, students may not be adequately prepared to navigate the ethical, legal and social issues surrounding AI in business.

Solutions to the Challenges of Artificial Intelligence in Business Education

Addressing the challenges of integrating artificial intelligence in Business education requires a multifaceted approach. By addressing these challenges, business education can effectively integrate artificial intelligence, preparing students for the future of work and fostering responsible artificial intelligence adoption in business through these approaches are briefly discussed below

- Investment in Technology: Strategic partnerships, collaborating with tech companies e.g. IBM, Microsoft, OpenAI for access to AI platforms and tools. Open-source Tools leveraging free or low-cost AI resources e.g., Python, TensorFlow, ChatGPT etc. Cloud-Based Learning Labs, using online AI labs to reduce hardware costs.
- Ethics and Responsible AI Education: Embed ethics in curriculum, integrating case studies on bias, data privacy and decision accountability. Using simulation to teach students how to handle ethical dilemmas in AI use which scenario-based learning.
- Faculty development: Offer training and support for faculty to develop AI expertise and teaching skills.
- Balance AI with human skills: Emphasize the complementarily of AI and human skills, like creativity and critical thinking.

Conclusion

Digital skills are required for the development of every sector of the economy. Effective skills in using technology, combined with the knowledge and competencies to innovate, can increase the ability of digital skills to the needs of the digital economy. Artificial Intelligence (AI) is an elaborate field that harbors various techniques and approaches used in developing intelligent machines capable of performing tasks that typically demand the application of human intelligence. Business Education must undergo significant transformation to remain relevant in this digital era by focusing on skill development, that can enable students to be quip with the tools necessary to thrive in the 21st century.

Recommendations

To ensure the successful integration of digital skills and AI technologies into business education programme, it is essential to adopt the best practices that can guide business educators and policymakers.

1. One of the key factors in the success of digital integration is ensuring that students and educators have access to reliable technology and high-speed internet. Governments

and institutions must prioritize investments in digital infrastructure, particularly in rural and underserved areas, to bridge the digital divide. Providing affordable access to devices and connectivity is essential to making digital skills inclusive and equitable.

2. The curriculum of business education should be reviewed from time to time to accommodate digital skills needed by students. This will enhance digital skill acquisition of students for job creation.
3. There should be provision for periodic retraining of business educators to update their knowledge in the various areas of ICT and in the use of ICT. This will expose them to modern trends in technology across the globe and enhance effective teaching.
4. The National Universities Commission (NUC) and the National Commission for Colleges of Education (NCCE) should work with industry to understand digital skills that are of strategic importance to the development of nation economy. This will help to align the programmes of business education in tertiary institutions with the real-world work practices.

References

Afonughe, E., Onah, E. N., Uzoma, A. C., Andor, S. E & Orisakew, C. U. (2021). Integration of artificial intelligence too; (AI-Chatbot) into teaching and learning: A Panacea for improving universities educational and administrative duties in South-South Nigeria. *Journal of Science and System Biology; 14(6), 1-6.*

Aina, M. A, Gbenga-Epebinu, Olofinibiyi, R. O., Ogidan, O. C. & Ayedun, T. O. (2023). Perception and acceptance of medical chatbot among undrgraduates in Ekiti State University, Nigeria. *British Journal of Education, 11(11), 1-14.*

Berglund, H. Bousfiha, M. and Mansoori, Y. (2020). Opportunities as artifacts and entrepreneurship as design. *Academy of management review*, 45(4), 825-846.

Edokpolor, J.E. and Owenvbiugie, R.O. (2017). Business educationin Nigeria: issue, challenge and way forward for national development. J*ournal of collaborative Research and Development* (JCRD), 5(1),1-2.

Elujekwute, E.C., Nwaokwa, E.O., Aja, J.O. and Oigoche, L. (2021). Business education and the achievement of sustainable development goals (SDGs) in Nigeria. *Sapientia Global Journal of Arts, Humanities and Development Studies* (SGOJAHDS), 4(3), 203-213.

Ezenwafor, J.I., & Onokpaunu, M.O. (2017). Perception of business educators on the relevance of integrating globalized workplace skills in the business education curriculum intertiary institutions in Nigeria. *Education & Science Journal of Policy Review and Curriculum Development, 7(1),1–10.*

Ferrari, A. (2013). *DIGCOMP: A framework for developing and understanding digital. competence in Europe.* Institute for Prospective Technological Studies. Published Augus http://ipts.jrc.ec.europa.eu/publications/pub**.cfm?id=6359.**

Gidado, S.D. and Akaeze, P. (2014). Role of business education in promoting Education entrepreneurship in Nigeria. Intrenational Journal of Academic Research in Progressive and Development, 3(4), 72-77.

Ibrahim, F.O. (2023). *The impact of emerging AI technologies on Nigerian. education*. Susa Africa, April, susaafrica.com

IDRA, (2018). *Artificial intelligence.* Emerging Technologies White Paper Series.

Ikpesu, O. C. (2017). Globalizing business education curriculum experiences in Nigeria higher education for enhanced students' employability. *European Journal of Business and Innovation Research,5(5), 47-57*

International Telecommunication Union. (2018). Digital skills toolkit. https:// www. itu .int/ en/ ITU /Digital -Inclusion/ Documents/ ITU %20Digital %20Skills %20Toolkit .pdf

Laara, E. V., Alexander, J.A.M., Dijka, V. & Haan, J. D. (2020). Measuring the levels of 21stcentury digital skills among professionals working within the creative industries: A performance-based approach. *Journal of Theoretical and Empirical Research 86(1), 1-14.*

Oguejiofor, C. S. (2020). Integrating e-commerce in business education curriculum for global competitiveness. *Nigerian Journal of Business Education, 7(1), 27 34.*

Okoro, J. (2015). Assessment of management competencies possessed by the University postgraduate business education students to handle entrepreneurship business challenges in Nigeria. *Journal of Education and Practice, 6(18), 129 -136.*

Okolocha, C.C., & Ile, C.M. (2012). Strengths of the business plan and industrial Collaboration strategies in the teaching of entrepreneurship in tertiary institutions in Anambra State, Nigeria. *International Journal of Arts and Humanities, 1(2), 246 – 261.*

Onokpaunu, M. O. (2016). Analysis of web-based instructional technologies for use by business education lecturers in tertiary institutions in Delta State. Unpublished Masters' Thesis, Department of Vocational Education, Faculty of Education, Nnamdi Azikiwe University, Awka.

Tripathy, M. (2019). The role of professional skills in digital transformation for Organizational effectiveness. *International Journal of Scientific & Technology Research. 8(10), 598-501.*

Tuomi, I.C. (2018). The impact of artificial intelligence on learning, teaching and education. Luxemboury; Publications office of the European Union. European Commission

Ugwoke, E.O. (2011). Effective utilization of ICT for repositioning business education Programme in tertiary institutions in Nigeria for national development. International Journal of Educational Research, 11 (1), 202 – 214.

UNESCO Institute of Statistics (2018). A global framework of reference on digital literacy Skills for indicator 4.4.2. Information Paper No. 51, UIS/2018/ICT/IP/51

PERCEIVED INFLUENCE OF MARKETING STRATEGIES ON ORGANIZATIONAL PERFORMANCE OF SMALL AND MEDIUM SCALE ENTERPRISES IN MAIDUGURI METROPOLIS, BORNO STATE

BY

MODU KORIMI[1] MOHAMMED GONI TELA[2]
Department of Business Education, Ramat Polytechnic Maiduguri Borno State, Nigeria.
E-mail - mkorimi64@gmail.com phone- 07032873880

Abstract

The study examined the influence of marketing strategies on organizational performance of small and medium scale enterprises in Maiduguri Metropolis. The study was also guided by two specific purposes, two research questions and two null hypotheses. The study adopted a descriptive research design. The population of the study comprised 826 registered SMEs in Maiduguri Metropolis. A sample size of 263 respondents were selected form the entire population using Taro Yamane sample size determination formula. The instrument used for data collection was a questionnaire titled "IMSOPSME" and was validated by three experts. A reliability coefficient of 0.79 was obtained using Chronbach's Alpha method. The data collected for the research questions were analyzed using mean and standard deviation. The null hypotheses were tested using independent samples t-test at 0.05significance level. The findings revealed that all the five marketing strategies (product and price) examined in the study influenced the organizational performance of SMEs to a high extent (Mean=3.48and3.35) and SD=0.55and0.53respectively. The study equally revealed that there was no significant difference between the mean rating of male and female managers of SMEs on the extent to which product and price marketing strategies influences the organizational performance of SMEs (t123= 1.238, P<0.05). Based on the findings, the study recommended that small and medium scale enterprise should always ensure that their product meet the specifications and the satisfaction of their consumers, development of varieties of products with new design, and features are right strategies for organization best performance.

Keyword: Small, Medium Enterprises, Organizational performance and Enterprises

Introduction

Organizations of all sizes, particularly small and medium-sized enterprises (SMEs), have recognized the need of developing strategies to enhance their understanding of the market, in relation to their competitors and clientele. Marketing enables organizations to effectively address the diverse demands of its clientele via the strategic coordination, implementation, and oversight of promotional initiatives. Dzisi and Ofosu (2014) claim that the adoption of sustainable marketing strategies might result in significant advantages for small and medium-sized enterprises (SMEs). Furthermore, it is commonly recognized that a considerable proportion of small firms encounter a lack of fundamental marketing capabilities. The managers often identified adverse market circumstances as a significant factor leading to their company's diminished market position. The circumstances emerged because of a lack of market intelligence, a scarcity of marketing tactics, poor product development and insufficient product commercialization. According to Adidu and Olannye (2016), there exists a variation in the definition of small and medium-sized businesses (SMEs) across different countries.

The small and medium-sized company (SME) sector plays a crucial role and acts as a vital component in several worldwide economies (Ademiluyi, 2014). The marketing efforts of small and medium-sized firms (SMEs) have played a vital role in accelerating economic development and achieving rapid industrialization in several developing countries. In accordance with the findings of Makati (2014). The small and medium-sized enterprises (SMEs) located in the city of Maiduguri are also not exempt from this phenomenon. The growth rate of small and medium-sized enterprises (SMEs) in Baga Motor park market is comparatively higher than that of SMEs in Gamboru Market due to the former's greater market accessibility. The market known as Monday market has the distinction of being the oldest and biggest market in Maiduguri, serving as a hub for a wide range of everyday commercial transactions (Joy, 2021). Marketing is a methodical strategy used by companies to generate customer interest in their goods and services. The process provides the foundational framework for sales tactics, corporate communication strategies, and organizational growth. Marketing is a multifaceted and integrated process in which organizations foster strong relationships with consumers and create reciprocal value for both parties involved.

According to Gajanayake (2016), marketing can be described as a systematic approach that entails the communication of the inherent value of a product or service to customers with the aim of stimulating its promotion. Marketing strategies involve a diverse array of techniques, tactics, procedures, or blueprints that are intended to be used by organizations or individuals with the objective of achieving or maintaining success in the marketplace. To enhance their long-term sustainability and maximize their marketing effectiveness, organizations must acquire the requisite knowledge and competencies to create and enhance effective marketing strategies. Marketing strategies are essential for the success of small and medium-sized firms (SMEs) operating in a fiercely competitive market environment. In the current era of intense competition, the lack of efficient marketing strategies hinders a corporation's ability to maintain its operations and achieve outstanding performance. Marketing strategies are of utmost importance in facilitating the expansion of market share and the mitigation of competitive pressures for small and medium-sized enterprises. The marketable strategies comprise a range of components, including product, pricing, marketing, distribution, and personnel. The anticipated outcome of small and medium-sized firms (SMEs) seeing increased profitability and sales may be attributed to the influence of marketing strategies, as shown by the research performed by Adewale, Adesola, and Oyewale (2013).

The identification and execution of pricing strategies are of paramount importance in bolstering a company's competitive edge. A range of pricing options are available to small and medium-sized organizations (SMEs).The notion of ancillary services pertains to supplementary offers that are supplied in conjunction with a primary product or service, with the objective of augmenting the total mean price. This objective can be achieved by employing various methodologies, such as incorporating pricing strategies that consider customers' psychological biases, integrating complementary products to enhance the value of physical offerings, implementing flat pricing structures, determining pricing based on individual characteristics and timing, and offering lower prices as a means of market penetration (Nimer & Smith, 2012). The determination of pricing for a recently released

product is widely acknowledged a sone of the most complex issues within the realm of marketing. If the price is overly elevated, it has the capacity to deter prospective clientele. On the other hand, if the price is too low, it might potentially. The outcome might lead to a significant decrease in prospective earnings and give rise to apprehensions over the caliber of the product or service being provided. The introduction of a novel product that is unfamiliar to consumers presents more significant obstacles in comparison to the launch of a new product within an established category. This is due to the lack of recognizable value standards, which adds complexity to the process. Moreover, it is important to acknowledge the presence of a deficiency in client understanding pertaining to the benefits of the innovative product. Furthermore, it has been observed that there is a lack of a well-defined purchase process, resulting in a hindrance to the distribution of essential information required for making educated buying choices (Hinterhuber & Liozu, 2017).

The implementation of promotional marketing methods plays a crucial role in shaping a brand's perception and reputation within the market. The impact of a creative promotion strategy on the placement of a product or service in customer perception is substantial. Hence, the role of marketing is crucial in effectively communicating information to customers about the most recent product offerings in the market, while also facilitating significant degrees of brand recognition and assessment.

Statement of the Problem

Small and medium-sized enterprises (SMEs) are significant in facilitating worldwide economic expansion and promoting progress. Small and medium-sized enterprises (SMEs) have inherent attributes that provide them the most viable and effective avenue for attaining self-sustaining economic development. Small and medium-sized enterprises (SMEs) in developing countries, like Nigeria, have considerable obstacles in sustaining their market presence and competitiveness in both domestic and international markets marked by intense competition. The performance of small and medium-sized enterprises (SMEs) in Nigeria has been below expectations, leading to their inability to effectively contribute to the country's economic growth and development. The prevalence of small business failure is a significant concern, necessitating an investigation into the marketing strategies and the impact on organizational success. Numerous scholarly investigations have been conducted to examine the impact of marketing techniques on the operational outcomes of small and medium-sized organizations (SMEs). To the best of the researcher's knowledge, there is a lack of prior research investigating the impact of marketing strategies on the organizational performance of small and medium-sized enterprises (SMEs) in the Maiduguri Metropolis. To address the identified deficiency that serves as the central focus of this study. The main aim of this research study is to investigate the influence of marketing strategies on the overall operational effectiveness of small and medium-sized firms (SMEs) situated in Maiduguri, Borno State.

Purposes of the Study

The main purpose of this study is to examine influence of marketing strategies on organizational performance of small and medium scale enterprises in Maiduguri Metropolis, Borno State. Specifically, the purposes of the study are to:

1. Examine the extent to which product marketing strategies influence organizational performance of small and medium scale enterprises.
2. Determine the extent to which price marketing strategies influence organizational performance of small and medium scale enterprises.

Research Questions

The following research questions will guide the study:

1. To what extent do product marketing strategies influence organizational performance of small and medium scale enterprises?
2. To what extent do price marketing strategies influence organizational performance of small and medium scale enterprises?

Research Hypotheses

The following research hypotheses are formulated and will be tested for this study at 0.05 level of significance.

1. **Ho1:** There is no significant different between the mean ratings of male and female SMEs managers regarding the perceived influence of product marketing strategies on organizational performance of small and medium scale enterprises.
2. **Ho2:** There is no significant different between the mean ratings of male and female SMEs managers regarding the perceived influence of price marketing strategies on organizational performance of small and medium scale enterprises.

Methodology

The study adopts a descriptive survey research design. 269 Small and Medium Scale enterprise operators in MMC and Jere Local Government Areas of Borno State were selected as sample out of a total population of 826 registered SMEs in the two local government using Yamane Taro sample size determination formula: See Appendix E. The sample size derived using the formula is 269. Purposive sampling and proportional sampling techniques were used to select100respondents from Jere L G A 169 respondents from MMC SMEs. Four-point rating scale researcher-made questionnaire was developed starting from Very High Extent' (VHE) 4 points; 'High Extent' (HE) 3 points; 'Low Extent' (LE) 2 points; and 'Very Low Extent' (VLE) 1point. The questionnaire comprises closed ended questions in line with the objectives of the study. The questionnaire contains two parts each; Part one and two, part 1seekstoestablish the respondents' demographic data while part two contains sections A-E with 16 questions to establish the respondents' opinions on the influence of marketing strategies on the organizational performance of SMEs. The questionnaire was validated by three experts from the department of business education university of Maiduguri. The reliability of the instrument was determined through a pilot test sampling of 30 SMEs Managers in Konduga local government area. The responses (data) obtained from the pilot test were collated. Cronbach Coefficient alpha (α) method was used to analyze the data collected from the pilot study to determine the internal consistency of the instrument. The result of the analysis revealed a reliability coefficient of 0.79 which shows that the instrument was reliable for gathering data. The researcher engaged four trained research assistants for the purpose of data collection in the area under study. A total of 269 copies of questionnaire were distributed and 264 were retrieved representing 98% return rate. Mean and standard deviation were used to analyze the data to answer the research questions while the independent sample t-test statistical was used to test the null hypotheses at 0.05 level of signifcance.

Results

Research Question One: To what extent do product marketing strategies influence performances of small and medium scale enterprises?

Table 1: Summary of descriptive statistics of respondents' mean ratings on the extent to which product marketing strategies influence organizational performance of SMEs?

N=263

S/N	Items	Mean	SD	Remarks
1	Introduction of new products periodically influence business performance of SMEs	3.76	0.62	VHE
2	Diversified products highly increase the revenue of SMEs	3.31	0.42	HE
3	Concentration on one main product would affect the SMEs	2.37	0.48	LE
4	The product packaging is key to the appeal of the product ,and Hence influence its demand.	3.53	0.50	VHE
5	If SMEs offer abroad product line ,it will improve them sales performance.	3.42	0.57	VHE
6	Having products with abroad market appeal will increase SMEs Market share.	3.34	0.69	VHE
7	SMEs' efficiency in meeting customer wants will increase their turnover.	3.58	0.49	VHE
8	If SMEs test the products to confirm their suitability to the target Customers ,it will increase demand.	3.53	0.58	VHE
	Grand Weighted Mean	3.48	0.55	VHE

Source: Field survey,2025

Table 1 reveals that Managers indicated that product marketing strategies influence organizational performance of SMEs is to high extent in the following areas: the introduction of new products periodically influence business performance of SMEs (Mean = 3.76), diversified products highly increase the revenue of SMEs (Mean = 3.31), concentration on one main product would affect the SMEs (Mean =3.37), The product packaging is key to the appeal of the product and hence influence its demand (Mean =3.53), If SMEs offer a broad product line, it will improve them sales performance (Mean = 3.42), Having products with a broad market appeal will increase SMEs market share. (Mean = 3.34), SMEs' efficiency in meeting customer wants will increase their turnover (Mean = 3.58), and that if they test their products to confirm their suitability to the target customers, it will increase demand (Mean=3.53).The standard deviations of the items are low from 0.41 to 0.69 indicating that their responses are too widespread. More specifically, the result indicated that product marketing strategies influence organizational performance of SMEs to a very high extent with (Grand Mean = 3.48; SD 0.55)

Research Question Two: To what extent do price marketing strategies influence organizational performance of small and medium scale enterprises?

Table2:Summaryofdescriptivestatisticsofrespondents'meanratingsontheextenttowhichpr ice marketing strategies influence organizational performance of SMEs

N=263

S/N	Items	Mean	SD	Remarks
9	Setting the same prices as competitors can impact the Performance of the SMEs positively.	3.64	0.48	VHE
10	Lowering of the prices can lead to better long-term SME Performance.	3.32	0.55	HE
11	Allowing customers to negotiate prices is good for the Performance SME.	3.70	0.54	VHE
12	Discounting prices of different products occasionally is helpful to SMEs 'business performance enhancement efforts.	3.44	0.50	HE
13	Quality transportation to deliver SMEs products to the markets enhance their performance.	3.49	0.50	HE
14	If SMEs price is not higher as compared to standard quality, It increases demand and profitability.	3.60	0.50	VHE
15	Market orientation of a product is important for product Pricing for improved performance of SMEs.	3.45	0.50	HE
16	Pricing is a basis for competition among micro and small Enterprises.	3.58	0.49	VHE
	Grand Weighted Mean	**3.35**	**0.53**	**HE**

Source: Field Survey2025

Table 2 reveals that Managers indicated that the extent to which price marketing strategies influence organizational performance of SMEs is very high in the following areas: that setting the same prices as competitors can impact the performance of the SMEs positively (Mean = 3.64), Lowering of the prices can lead to better long-term SME performance (Mean = 3.32), Allowing customers to negotiate prices is good for the performance of SME (Mean =3.70), Discounting prices of different products occasionally is helpful to SMEs' business performance enhancement efforts (Mean = 3.44), Pricing is a basis for competition among micro and small enterprises (Mean = 3.49), Quality transportation to deliver SMEs products to the markets enhance their performance (Mean = 3.60), If SMEs price is not higher as compared to standard quality, it increases demand and profitability (Mean = 3.50), and that market orientation of a product is important for product pricing for improved performance of SMEs (Mean = 3.58). The standard deviations of the items are low from 0.48 to 0.50 indicating that their responses are too widespread. More specifically, the result indicated that price marketing strategies influence organizational performance of SMEs to a very high extent with (Grand Mean = 3.35; SD 0.53).

Test of Hypotheses

The two null hypotheses of the study were tested using independent sample t-test. The null hypotheses were tested at 0.05 level of significance.

Ho1: There is no significant difference between the mean ratings of male and female SMEs managers regarding the influence of product marketing strategies on organizational performance of small and medium scale enterprises

Table3: Independent Sample t-test analysis male and female manager one extent to which product marketing strategies influence organization performance of SMEs

Group	N	Mean	SD	t-cal	DF	P-value	Decision
Male	71	3.4894					
			0.1209	1.398	261	0.000	Rejected
Female	192	3.4596	0.2185				

Source :Field Survey 2024 P<0.05

The data in table 3 reveals that there are 71 male and 192 female managers of SMEs. The male and female managers' responses show that the extent to which product marketing strategies influence organization performance of SMEs is very high (Mean = 3.49; SD = 0.12) **(**Mean = 3.46; SD = 0.22). Their responses are close to the mean as the standard deviations are very low. The Table reveals that there was a significant difference between the mean ratings of male and female managers of SMEs on the extent to which people marketing strategies influence the organization performances in Ilorin metropolis ($t_{261} = 1.398$, $P < 0.05$). Therefore, the null hypothesis that states that there is no significant difference between the mean ratings of male and female SMEs managers on the extent to which product marketing strategies influence organization performance was rejected. This implies that managers of SMEs both male and female differ in their responses regarding extent to which product marketing strategies influence the organization performance. Similarly, their responses disclosed that male SMEs managers rated the influence of product marketing strategies on organization performance higher than their female counterpart did (mean difference = 0.03)

Ho2: Male and female managers of SMEs do not differ significantly in their mean ratings regarding the influence of price marketing strategies on organizational performance of small and medium scale enterprises

Table4: Independent Sampled-test analysis male and female manager on extent to which price marketing strategies influence organization performance of SMEs

Group	N	Mean	SD	t-cal	DF	P-value	Decision
Male			0.1778				
	71	3.5405		0.564	261	.000	**Ho2 Rejected**
Female	192	3.5286	0.1401				

Source: Field Survey2024 P<0.005

The data in table 4 reveals that there are 71 male and 192 female managers of SMEs. The male and female managers' responses show that the extent to which price marketing strategies influence organization performance of SMEs is very high (Mean = 3.54; SD = 0.18) **(**Mean = 3.53; SD = 0.14). Their responses are close to the mean as the standard deviations are very low. The Table reveals that there was a significant difference between the mean ratings of male and female managers of SMEs on the extent to which price marketing strategies

influence the organization performances in Maiduguri metropolis ($t_{261} = 0.564$, $P < 0.05$). Therefore, the null hypothesis that states that there is no significant difference between the mean ratings of male and female SMEs managers on the extent to which price marketing strategies influence organization performance was rejected. This implies that managers of SMEs both male and female differ in their responses regarding extent to which price marketing strategies influence the organization performance. Their responses equally showed that male managers of SMEs rated the influence of price marketing strategies on organization performance higher than their female counterpart (mean difference = 0.012).

Discussion of Findings

The study investigated the perceived influence of marketing strategies on performance of small and medium scale enterprises in Borno State. The study investigated two key components of marketing strategies, including product, pricing, promotion, place, and people marketing strategies. The findings of the study, as presented in Table 1, suggest that product marketing strategies have a significant impact on the organizational performance of small and medium-sized enterprises (SMEs). This suggests that the adoption and implementation of product marketing strategies have a substantial impact on the optimal performance of small and medium-sized enterprises. The findings align with the assertions made by Gbolagade, Adesola, and Oyewale (2013), who posited that the marketing strategy of a product exerts a substantial impact on the performance of a business. The present findings provide support for the previous research conducted by Mustapha (2013), who similarly argued that the product encompasses its tangible attributes such as its physical look, packaging, and labeling information. These factors have the potential to impact consumer behavior, influencing whether individuals take notice of a product when in retail setting, engage in an examination of it, and ultimately make purchase. The study reveals a strong correlation between product marketing strategies and the organizational performance of small and medium-sized enterprises (SMEs), which aligns with the findings of Wawira (2016). Wawira's analysis of the marketing mix demonstrated that factors such as quality assurance, brand popularity, product diversification, packaging, and production volume significantly impacted market share.

The results shown in Table 2 indicate a statistically significant disparity in the average assessments of male and female managers of small and medium-sized enterprises (SMEs) about the impact of people-oriented marketing strategies on organizational performance. This finding is not unexpected; as Omotayo and Adegbuyi (2015) discovered that the establishment of an effective product development strategy enhances brand recognition and generates a notable beneficial impact on sales performance. One notable aspect of significance is in the implementation of product marketing strategies by small and medium enterprises (SMEs) to improve their overall performance. It is plausible that Ebitu (2016) discovered in a previous investigation that Nigeria shown a noteworthy influence of product quality strategy and relationship marketing strategy on the profitability and augmented market share of small and medium-sized enterprises (SMEs).

The results presented in Table 3 indicate a strong and significant relationship between price marketing tactics and the organizational performance of small and medium-sized enterprises (SMEs). This aligns with the findings of Wawira (2016), who observed that among the various elements of the marketing mix, price is the sole strategy that generates sales income, while all other strategies incur costs. According to Cornelissen (2019), pricing serves as a crucial criterion for commercial and industrial clients when evaluating the value ofa product or service. Furthermore, it significantly influences the decision-making process in terms of

brand selection when faced with various competing options. The observation that pricing marketing strategies significantly impact the organizational performance of small and medium-sized enterprises. SMEs align with the assertion made by Vikas (2011). Vikas posited that pricing strategy involves establishing a relatively low initial price for a new product or brand with the aim of achieving a competitive advantage in a fiercely contested market. The implementation of a price strategy is applicable in scenarios when a novel product is being introduced to the market or when targeting a previously untapped market segment for an existing product. It is noteworthy thatthe study revealed a considerable disparity in the mean scores of male and female managers about the impact of pricing marketing tactics on the performance of small and medium-sized enterprises (SMEs). The research conducted by Owomoyela, Oyeniyi, and Ola (2013) clearly demonstrates the existence of a substantial correlation between price and business performance. The pricing strategy employed for a product or service significantly influences its market appeal. According to the findings of Adesola and Oyewale (2013), the factor of pricing consideration was found to have a notable and favorable influence on the overall performance of businesses.

Conclusion

The study's findings indicate that the organizational performance of SMEs is highly influenced by each of the two strategies for marketing analyzed in the study, namely product, and pricing. This study clearly shown the efficacy of marketing strategies in enhancing the operational performance of small and medium-sized enterprises (SMEs) located in Ilorin metropolis. Therefore, it could be concluded that those strategies are the effective aspect of marketing strategies which are paramount for small firms to sustain strong performance in their business operations.

Recommendations

1. Small and Medium-Sized Enterprises (SME) should always ensure that their products meet the specifications and expectations of their customers, and the development of new product varieties with innovative designs and features are the best strategies for achieving optimal performance.
2. When developing a pricing strategy, small and medium-sized businesses should consider what their competitors are charging for the same product or service, offer discounts, and consider the value of consumers who purchase their products.
3. Small and medium-sized businesses should employ the correct promotional tools that facilitate brand awareness and lead generation, particularly on social media.

References

Ademiluyi,L.,F.(2014).PersonalityQualitiesNeededforSuccessfulEntrepreneurshipinNigeria.Tij's Research *Journal of Social Science & Management* - Rjssm, 4

Cornelissen,J.(2019).*CorporateCommunication:*AGuidetoTheoryandPractice,*2nd Edition*.SAGE Publishers.

Dzisi, S., & Ofosu, D. (2014). Marketing Strategiesand the Performance of SMEsin Ghana. *European Journal of Business and Management, 6*(5), 102 - 111.

Ebitu,E.T.(2016).“MarketingStrategiesandthePerformanceofSmallandMediumEnterprisesinAkwa Ibom State, Nigeria.*British Journal of Marketing Studies, 4*(5), 51-62.

Gbolagade, A., Adesola M.A. &Oyewale I. O. (2013). Impact of Marketing Strategy on Business Performance: A Study of Selected Small and Medium Enterprises (SMEs) In Oluyole Local Government, Ibadan, Nigeria. *IOSR Journal of Business and Management, 11*(4), 59-66.

Hinterhuber, A. & Liozu, S. M. (2017). Is Innovation in Pricing Your Next Source of Competitive Advantage? Innovation in Pricing. *Contemporary Theories and Best Practices, 2nd Edition*, 11–28. https://doi.org/10.4324/9781315184845

Makate, C. (2014). Determinants of Small to Medium Enterprises Performance in the Zimbabwean Informal Metal Fabrication Industry: Evidence from Firm Level Data. *Journal of Economics,2*(10), 1-12.

Manijeh, H., Bahram, S., Mina, E. & Parastoo, R. (2013). Identification of Innovative Marketing Strategies to Increase the Performance of SMEs in Iran. *International Journal of Fundamental Psychology and Social Sciences,3*(2), 26 -30.

Mustapha,B.(2013).*MarketingManagement:AnIntroductoryApproach*.Skisoftpublishing Co.

Owomoyela, S.K., Oyeniyi, K.O. & Ola, O.S. (2013). Investigating the Impact of Marketing Mix Elements on Consumer Loyalty: An Empirical Study on Nigerian Breweries Plc. *Interdisciplinary Journal of Contemporary Research in Business, 4*(11): 485-496.

Owomoyela, S.K., Oyeniyi, K.O. & Ola, O.S. (2013). Investigating the Impact of Marketing Mix Elements on Consumer Loyalty: An Empirical Study on Nigerian Breweries Plc. *Interdisciplinary Journal of Contemporary Research in Business, 4*(11): 485-496.

Wawira, P. L. (2016). Marketing Strategies and Performance of Large Hotels in Nairobi County. *Doctoral dissertation*, University of Nairobi.

INTEGRATING ARTIFICIAL INTELLIGENCE INTO TEACHING BUSINESS EDUCATION SUBJECTS: ENHANCING LEARNING AND ENTREPRENEURSHIP IN RAMAT POLYTECHNIC, MAIDUGURI

***[1]Mustapha Ali, [2]Bashehu Saleh and [1]Mohammed Goni Tela**
[1]Department of Business Education, Ramat Polytechnic Maiduguri
[2]Entrepreneurship Development Centre Ramat Polytechnic, Maiduguri
Corresponding author Email: mustaphagoni1057@gmail.com
Phone No. 08133241258

ABSTRACT

This study examines the integration of Artificial Intelligence (AI) into teaching business education subjects to enhance learning and entrepreneurship at Ramat Polytechnic, Maiduguri. The study is guided by three objectives: examining the current state of AI integration, identifying challenges hindering its adoption, and exploring its potential impact on entrepreneurial skills development. The study employs a descriptive survey research design. The population consists of 18 lecturers from the Department of Business Education, with a census approach adopted for data collection. A structured questionnaire was used as the primary instrument, and data were analyzed using descriptive statistics, including mean and standard deviation. Findings reveal that AI adoption remains minimal due to inadequate infrastructure, limited faculty expertise, and resistance to change. Key challenges include high costs, poor internet connectivity, and a lack of structured policies. Despite these barriers, AI is recognized for its potential to enhance decision-making, problem-solving, and business efficiency in entrepreneurship education. Based on the findings, the study recommends increased investment in AI infrastructure, faculty training, and curriculum integration. Policymakers and stakeholders must prioritize AI-driven educational strategies to equip students with essential skills for digital entrepreneurship and evolving business landscapes.

Keywords: Artificial Intelligence, Business Education Subjects, Learning and Entrepreneurship

1. INTRODUCTION

Entrepreneurship education has gained significant recognition globally as a crucial driver of economic growth and innovation. It plays a fundamental role in equipping individuals with the necessary skills to identify opportunities, develop innovative solutions, and create successful business ventures. Governments and policymakers worldwide advocate for the integration of entrepreneurship education into academic curricula, particularly in higher education institutions. This integration is seen as a means to enhance employability, generate employment, and foster a culture of innovation among young people (Kuratko & Hornsby, 2023; OECD, 2024). As economies become increasingly knowledge-driven, the importance of entrepreneurship education continues to grow, ensuring that graduates possess the competencies needed to navigate an ever-evolving business landscape.

Business education, particularly within tertiary institutions, serves as a foundational pillar for entrepreneurship by providing students with the theoretical knowledge and practical skills required to thrive in competitive markets. It covers essential aspects such as financial

management, business planning, marketing strategies, and leadership development. Through structured curricula and experiential learning opportunities, students are exposed to real-world business scenarios that prepare them for entrepreneurial challenges. However, for business education to remain relevant and effective, it must continuously adapt to technological advancements and industry demands. One of the most significant advancements shaping the future of business education is the integration of Artificial Intelligence (AI), which has the potential to revolutionize teaching and learning methodologies.

The emergence of the Fourth Industrial Revolution has transformed various sectors, including business and education, by introducing cutting-edge technologies such as AI, automation, and big data analytics. In this rapidly evolving landscape, integrating AI into business education has become increasingly crucial. AI-powered tools can enhance the learning experience by providing personalized real-time feedback, automating routine administrative tasks, and facilitating the development of critical analytical skills essential for entrepreneurship (Chen *et al.,* 2024). These capabilities enable students to engage with complex business concepts in a more interactive and efficient manner. However, despite the evident benefits of AI, many business education curricula still lack comprehensive AI integration, leaving students unprepared for AI-driven industries (Singh & Patel, 2023; Wang & Lee, 2024).

The limited incorporation of AI in business education can be attributed to several challenges, including inadequate infrastructure, lack of trained faculty, and resistance to change among educators and institutions. Many traditional business education programs continue to rely on conventional teaching methods, which may not fully equip students with the technological proficiency required in modern entrepreneurial settings. Additionally, the cost of implementing AI-powered learning systems and the need for continuous curriculum updates pose significant barriers to AI adoption. Overcoming these challenges requires a concerted effort from academic institutions, policymakers, and industry stakeholders to invest in AI-driven educational strategies that align with global technological advancements.

This study specifically examines the integration of AI into business education at Ramat Polytechnic, Maiduguri, a leading institution committed to fostering entrepreneurship among its students. By leveraging AI tools, the research aims to enhance learning experiences, improve entrepreneurial skills, and prepare students for digital entrepreneurship in an increasingly competitive global market. The study investigates how AI can be effectively incorporated into business courses to bridge the existing skills gap and empower students with the knowledge needed to thrive in AI-driven industries.

2. STATEMENT OF THE PROBLEM

Despite the growing importance of Artificial Intelligence (AI) in modern entrepreneurship and business education, Ramat Polytechnic, Maiduguri, has yet to fully integrate AI into its business education curriculum. As industries become increasingly AI-driven, the lack of AI incorporation in teaching methods leaves students unprepared for the demands of digital entrepreneurship and data-driven decision-making. It is also likely that challenges such as inadequate infrastructure, limited faculty expertise, and resistance to technological change are contributing factors to the slow adoption of AI in the curriculum. Furthermore, traditional teaching methods may no longer be sufficient to equip students with the competencies required for competitive and innovation-driven markets. This study explores the possibility that integrating AI into business education at Ramat Polytechnic could enhance

learning experiences, improve entrepreneurial skills, and better prepare students for the demands of AI-driven industries.

3. OBJECTIVES OF THE STUDY

The objectives of the study are to:

1. Examine the current state of AI integration in business education at Ramat Polytechnic, Maiduguri
2. Identify the challenges hindering the effective incorporation of AI into the business education in Ramat Polytechnic.
3. Explore the potential impact of AI integration on entrepreneurial skills development

4. RESEARCH QUESTIONS

1. What is the current state of AI integration in business education at Ramat Polytechnic, Maiduguri?
2. What challenges hinder the effective incorporation of AI into business education at Ramat Polytechnic?
3. How does AI integration impact entrepreneurial skills development among students at Ramat Polytechnic?

5. LITERATURE REVIEW

The rapid evolution of artificial intelligence (AI), data analytics, and digital marketing is reshaping global education systems, necessitating their integration into business education curricula. As Nigerian higher education institutions strive to keep pace with these advancements, recent studies have examined the extent of AI adoption, student perspectives, and its impact on learning and entrepreneurship. The following research findings highlight key trends, challenges, and opportunities in AI and digital education within Nigerian tertiary institutions. These insights underscore the urgent need for balanced curriculum development, technological infrastructure improvements, and institutional support to maximize AI's potential in education and business.

A pertinent study by Ufondu and Obi (2024), investigates the extent of AI, data analytics, and digital marketing integration in Nigerian business education curricula. The research reveals that AI and data analytics are incorporated to a low extent, whereas digital marketing is integrated to a high degree. This disparity suggests a need for balanced curriculum development to equip students with comprehensive digital competencies.

Similarly, research by Abubakar, Onasanya, and Ibrahim (2024), explored student perspectives on AI integration in pedagogical practices within Nigerian tertiary institutions. The study found a moderate level of awareness among students regarding AI's potential benefits in education. Students expressed strong belief in AI's role in improving learning experiences but voiced concerns about technical difficulties, privacy issues, and the adequacy of training and support for AI technologies. These findings underscore the need for increased awareness, technological infrastructure improvements, and targeted support services to facilitate effective AI integration in teaching and learning.

A study by Eteng-Uket and Effiom (2024), investigated higher education students' attitudes toward AI-based educational interventions for learning. Conducted at the University of Port Harcourt, the research employed a descriptive survey design with a sample of 150 students. The findings revealed that 98% of students had a positive attitude toward AI-based educational interventions. However, gender and age did not significantly influence their attitudes. These results suggest that students are receptive to AI in education, highlighting the

importance of familiarizing educators with AI tools and encouraging students to leverage AI for learning and research.

A study by Efuetanu (2024), investigated the impact of AI training programs on entrepreneurship skills development among Nigerian university students. The research demonstrated that participation in AI-focused training significantly enhanced students' problem-solving abilities, creativity, and business acumen. These skills are essential for entrepreneurial success, highlighting the potential of AI education to foster innovation and business leadership.

Additionally, a study by Okeseeyin (2024), examined the role of AI in supporting entrepreneurial activities among business students in Nigerian higher education institutions. The findings indicated that AI tools facilitated market analysis, customer engagement, and business strategy development, thereby enhancing students' entrepreneurial capabilities. However, challenges such as limited access to AI resources and insufficient training were identified, suggesting the need for institutional support and infrastructure development to fully leverage AI's potential in entrepreneurship education.

5.1 Theoretical Framework

Fred D. Davis (1989), Technology Acceptance Model (TAM) was used in the study which was extension of the Theory of Reasoned Action (TRA) by Fishbein and Ajzen (1975). Davis introduced TAM to provide a framework for understanding how users come to accept and use technology, particularly in organizational and educational contexts.

TAM posits that users' acceptance of new technology is primarily determined by two key factors: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU**)**. Perceived Usefulness refers to the degree to which a person believes that using a specific technology will enhance their performance or productivity. In the context of education, this could be how beneficial students and faculty find Artificial Intelligence (AI) in improving learning outcomes and entrepreneurship skills. Perceived Ease of Use refers to the degree to which a person believes that using the technology will be free from effort. Even if a technology is useful, if it is difficult to use, it may not be adopted.

These two factors PU and PEOU directly influence an individual's attitude toward using the technology, which then affects their behavioral intention to use it **and ultimately leads to the** actual use of the system. TAM emphasizes that the ease with which a technology can be used, in combination with its perceived benefits, plays a critical role in determining whether individuals will adopt and use it.

TAM is relevant to the study because it provides a framework to assess how students and faculty perceive AI-based educational tools. The study used TAM to explore whether business education students and instructors believe that AI will enhance their learning and entrepreneurial skills, thus determining its perceived usefulness.

6. METHODOLOGY

Descriptive survey research design was adopted to investigate the integration of artificial intelligence (AI) into teaching business education subjects at Ramat Polytechnic, Maiduguri. The study focuses on gathering information exclusively from lecturers to understand their perceptions, awareness, and readiness for AI adoption in business education.

The descriptive survey research design is appropriate for this study as it enables the researcher to systematically collect, analyze, and interpret data regarding lecturers' experiences and perspectives on AI integration (Creswell & Creswell, 2018). This design is widely used in educational research when the goal is to assess attitudes, knowledge, and

challenges faced by educators in adopting new technologies (Fraenkel, Wallen, & Hyun, 2019).

6.1 Population

The population of the study consists of all 18 lecturers from the Department of Business Education at Ramat Polytechnic, Maiduguri. Given the relatively small and manageable size of the population, no sampling was conducted; instead, a **census approach** was adopted, ensuring that all lecturers participated in the study. The **census approach** is recommended when the population is small, as it eliminates sampling error and provides a more comprehensive and accurate representation of the target group (Kothari, 2004; Creswell & Creswell, 2018).

Adopted and modified questionnaire from Abubakar, Onasanya, and Ibrahim (2024), was used to obtain relevant information on lecturers' perceptions, awareness, readiness, and challenges related to AI integration in business education. Data collected were analyzed using descriptive statistics (m**ean and standard deviation)** to interpret the responses. The mean was used to determine the overall trend of lecturers' opinions on AI integration, while the standard deviation provided insight into the variability of their responses.

7. RESULTS AND DISCUSSION

Table 1. Mean and Standard Deviation Distribution of the Respondents Based on the current state of AI integration in business education at Ramat Polytechnic, Maiduguri

S/N	Item Statement	Mean	SD
1	I am familiar with AI technologies in the context of business education.	2.1	0.8
2	AI tools or platforms are currently being used in business education at Ramat Polytechnic.	1.8	0.7
3	AI plays a significant role in enhancing business education.	2.0	0.9
4	The integration of AI in business courses provides significant benefits.	2.2	1.0
5	AI-related courses or modules are offered in the business department.	1.7	0.6
6	AI is currently being incorporated into teaching methodologies at Ramat Polytechnic.	1.9	0.7
7	AI-powered tools are used in business classes.	1.6	0.5
8	I frequently use AI-based tools in my teaching process.	1.5	0.4
9	Students are encouraged to use AI applications.	1.8	0.6
10	The use of AI in business education presents several challenges.	4.2	1.1
11	Ramat Polytechnic provides training for lecturers on AI usage in education.	1.7	0.5
12	There is sufficient institutional support (e.g., funding, technical assistance) for AI integration.	1.6	0.4
13	The institution has policies or guidelines for AI adoption in Bus. Edu.	1.8	0.6
14	The available infrastructure (e.g., internet access, AI software) supports AI integration.	1.9	0.7
15	Ramat Polytechnic collaborates with external organizations to enhance AI adoption in business education.	1.8	0.6
16	AI improves student engagement and learning outcomes.	2.0	0.8
17	Students respond positively to AI-based learning tools in Bus. courses.	1.9	0.7
18	More efforts are needed to improve AI integration in business education at Ramat Polytechnic. *(Higher score = More need for improvement)*	4.5	1.2
19	Future AI developments will greatly enhance the institution's business	2.3	1.0

	programs.		
20	AI will significantly transform business education in the next five years.	2.1	0.9
—	**Grand Mean**	**2.12**	**—**

Source: Field Survey, 2025

The findings from the table indicate a low level of AI integration in the Business Education department at Ramat Polytechnic, Maiduguri. With a Grand Mean of 2.12, it is evident that lecturers have limited familiarity with AI technologies, and its adoption in teaching and learning remains minimal. The low mean scores in items related to AI usage (1.5 to 2.1) suggest that AI-powered tools, such as chatbots and adaptive learning systems, are rarely implemented in the department.

Additionally, the lack of institutional support, training, and infrastructure further hinders AI integration. The responses indicate that there are insufficient training programs, policies, and technical resources to support AI adoption, as reflected in mean scores between 1.6 and 1.9 for items related to institutional support. Moreover, the high mean score of 4.2 for the challenges of AI in business education suggests that lecturers perceive significant obstacles to its adoption, including lack of funding, technical expertise, and resistance to change.

Despite these challenges, lecturers acknowledge the need for improvement in AI adoption, with item 18 recording the highest mean score of 4.5. This indicates a strong consensus that urgent efforts are required to enhance AI integration in business education. Furthermore, while responses related to the future potential of AI in education (items 19 and 20) show some optimism, their relatively low mean scores (2.3 and 2.1) suggest uncertainty about whether the institution is ready to embrace AI-driven innovations.

In conclusion, while AI is recognized as an important tool for improving business education, its adoption at Ramat Polytechnic remains limited due to low familiarity, lack of training, and institutional challenges. To address these issues, there is a need for comprehensive training programs, policy development, and investment in AI tools and infrastructure to facilitate its successful integration into business education.

Table 2. Mean and Standard Deviation Distribution of the Respondents Based on the challenges hindering the effective incorporation of AI into the business education in Ramat Polytechnic.

S/N	Item Statement	Mean	SD
1	Lack of AI awareness and knowledge among lecturers hinders AI adoption.	4.3	1.1
2	Insufficient training and workshops limit AI integration in business education.	4.5	1.2
3	Inadequate institutional policies and guidelines prevent AI adoption.	4.2	1.0
4	Limited access to AI tools and software affects AI incorporation in teaching.	4.6	1.3
5	Poor internet connectivity restricts the use of AI-driven learning resources.	4.4	1.1
6	High cost of acquiring AI technology and infrastructure is a major challenge.	4.7	1.3
7	Resistance to change among lecturers affects AI integration.	4.1	1.0
8	Lack of AI-related curriculum content slows AI adoption.	4.3	1.1
9	Inadequate government and institutional funding hinders AI implementation.	4.6	1.2
10	Ethical and privacy concerns limit the use of AI in business education.	4.0	0.9
11	Lack of collaboration with AI experts and industry stakeholders affects AI	4.2	1.0

	learning.		
12	Students have limited knowledge and exposure to AI applications.	4.3	1.1
13	AI integration requires technical expertise that is currently lacking.	4.5	1.2
14	Fear of job displacement discourages lecturers from embracing AI.	4.0	0.9
15	There is no structured roadmap for AI adoption in business education.	4.2	1.0
16	AI tools are not tailored to meet the specific needs of business education.	4.1	1.0
17	Unclear benefits of AI in business education limit its acceptance.	4.0	0.9
18	Lack of technical support discourages lecturers from using AI tools.	4.4	1.1
19	Business education at Ramat Polytechnic does not prioritize AI integration.	4.5	1.2
20	More research is needed to develop effective AI strategies in business education.	4.3	1.1
—	**Grand Mean**	**4.3**	**—**

Source: Field Survey, 2025

The findings indicate that several key challenges hinder the effective incorporation of AI into business education at Ramat Polytechnic, Maiduguri. The Grand Mean of 4.3 suggests that lecturers strongly agree that multiple obstacles limit AI integration, ranging from lack of awareness and training to inadequate institutional support and funding.

One of the most critical challenges identified is the high cost of acquiring AI technology and infrastructure (Mean = 4.7, SD = 1.3), which suggests that financial constraints are a major barrier to AI adoption. Similarly, inadequate government and institutional funding (4.6), limited access to AI tools (4.6), and poor internet connectivity (4.4) further contribute to the difficulty in implementing AI-based learning systems. Without sufficient financial and technological investment, AI integration remains limited.

Another major issue is the lack of AI awareness, training, and technical expertise among lecturers. Insufficient training programs (4.5), lack of AI-related curriculum content (4.3), and the absence of structured AI adoption policies (4.2) indicate that lecturers lack the necessary skills and knowledge to effectively use AI in their teaching. Additionally, resistance to change (4.1) and fear of job displacement (4.0) suggest that some lecturers may be hesitant to adopt AI due to concerns about its impact on traditional teaching methods.

Institutional and external support also plays a crucial role in AI adoption. The lack of collaboration with AI experts and industry stakeholders (4.2), absence of a structured roadmap for AI adoption (4.2), and insufficient technical support (4.4) highlight the need for strategic partnerships and clear policies to facilitate AI integration. Furthermore, ethical and privacy concerns (4.0) and unclear benefits of AI in business education (4.0) suggest that some lecturers remain uncertain about the potential advantages of AI in the learning environment.

Despite these challenges, the responses indicate a strong need for further research and strategic planning to enhance AI adoption. The mean score of 4.5 for the lack of prioritization of AI in business education emphasizes that AI has not yet been fully embraced as a critical component of the curriculum. Additionally, the need for more research on AI strategies (4.3) indicates that lecturers recognize the importance of developing effective implementation frameworks for AI in business education.

The findings reveal that the integration of AI in business education at Ramat Polytechnic is significantly hindered by financial, technical, institutional, and attitudinal challenges. Addressing these obstacles requires investment in AI infrastructure, comprehensive training programs, policy development, and industry collaboration. Without

these efforts, AI adoption will remain slow, limiting its potential to enhance teaching and learning in business education.

Table 3. Mean and Standard Deviation Distribution of the Respondents Based on potential impact of AI integration on entrepreneurial skills development

S/N	Item Statement	Mean	SD
1	AI enhances students' ability to analyze business trends and market demands.	4.5	1.2
2	AI tools improve students' decision-making skills in business scenarios.	4.6	1.3
3	AI-powered simulations help students develop entrepreneurial problem-solving skills.	4.4	1.1
4	AI fosters creativity and innovation in student entrepreneurial projects.	4.3	1.0
5	AI assists students in business planning and strategy formulation.	4.5	1.2
6	AI-driven analytics help students understand consumer behavior and market competition.	4.6	1.3
7	AI applications improve students' ability to manage business finances.	4.2	1.0
8	AI-based learning platforms provide students with access to business development resources.	4.4	1.1
9	AI enhances students' adaptability to digital transformation in business.	4.5	1.2
10	AI encourages students to develop innovative business models and startups.	4.3	1.0
11	AI-powered automation tools help students improve business efficiency and productivity.	4.6	1.3
12	AI enhances students' skills in e-commerce and digital marketing.	4.5	1.2
13	AI-driven mentorship and chatbots support students in entrepreneurial learning.	4.3	1.1
14	AI tools improve students' networking and collaboration skills in entrepreneurship.	4.2	1.0
15	AI-based business forecasting helps students assess risks and opportunities.	4.6	1.3
16	AI promotes critical thinking and innovation in entrepreneurial decision-making.	4.5	1.2
17	AI integration in business education equips students with practical entrepreneurial skills.	4.4	1.1
18	AI helps students develop a global perspective in entrepreneurship.	4.3	1.0
19	AI enhances students' ability to use emerging technologies in business ventures.	4.5	1.2
20	More AI-driven initiatives should be introduced to support entrepreneurial skill development.	4.6	1.3
—	**Grand Mean**	**4.45**	—

Source: Field Survey, 2025

The findings suggest that AI integration plays a crucial role in enhancing entrepreneurial skills development among students at Ramat Polytechnic. With a Grand Mean of 4.45, the responses indicate that lecturers strongly agree that AI provides significant benefits in equipping students with essential business and entrepreneurial competencies.

One of the key areas where AI demonstrates high impact is in decision-making, business forecasting, and market analysis. The high mean scores (4.6 – 4.7) in these aspects suggest that AI-powered tools enable students to assess risks, understand consumer behavior, and develop data-driven business strategies. AI-driven simulations and analytics also support problem-solving and strategic planning, which are essential for entrepreneurial success.

Additionally, AI fosters innovation, creativity, and adaptability in business ventures. The mean scores of 4.3 – 4.5 in areas such as business model development, e-commerce skills, and digital transformation adaptability highlight AI's role in preparing students for modern entrepreneurial challenges. AI-driven mentorship tools, automation platforms, and networking applications further enhance collaborative learning and real-world business exposure.

The findings also emphasize the importance of financial and resource management through AI applications. With a mean of 4.2 – 4.4, lecturers recognize that AI assists students in financial planning, resource optimization, and business efficiency, which are critical components of entrepreneurial growth. AI-based platforms provide access to business resources, mentorship programs, and automation tools, helping students gain practical experience in managing business operations.

Furthermore, the study reveals that AI integration encourages a global perspective in entrepreneurship. The mean scores for global business adaptability, use of emerging technologies, and AI-driven innovations (4.3 – 4.5) suggest that AI helps students align their entrepreneurial ventures with international business trends.

Despite these advantages, the results indicate that more AI-driven initiatives should be introduced (Mean = 4.6), suggesting that while AI has proven beneficial, there is still a need for further investment in AI-based learning strategies to maximize its impact on entrepreneurial skill development.

The findings confirm that AI is a powerful tool for enhancing entrepreneurial education at Ramat Polytechnic. Its ability to improve decision-making, foster innovation, enhance business planning, and support financial management makes it a valuable asset for students. However, to fully harness AI's potential, the institution should expand AI integration through additional initiatives, investments, and training programs to equip students with the necessary skills for success in the evolving business landscape.

8. SUMMARY OF FINDINGS

1. AI adoption in the Business Education department at Ramat Polytechnic is minimal due to limited lecturer familiarity, inadequate institutional support, and poor infrastructure. Challenges such as funding constraints, lack of technical expertise, and resistance to change further hinder its implementation. While AI's potential is recognized, uncertainty persists regarding the institution's readiness for full integration.
2. AI adoption faces significant barriers, including high costs, insufficient funding, and limited access to AI tools. Poor internet connectivity, lack of technical expertise, and absence of structured policies further restrict implementation. Ethical concerns, resistance to change, and fear of job displacement discourage lecturers from embracing AI, while the lack of prioritization in the curriculum calls for urgent strategic planning.
3. AI enhances students' decision-making, problem-solving, and innovation in entrepreneurship. It supports financial planning, business efficiency, and adaptability to digital transformation. While AI significantly benefits entrepreneurial education,

more initiatives, investments, and training programs are needed to maximize its impact.

9. CONCLUSION

AI has the potential to transform business education, but financial, technical, and institutional barriers limit its adoption. Addressing these challenges through investment, training, and policy development is crucial for effective integration.

10. RECOMMENDATION

Based on the findings, the following recommendations were made:

1. Ramat Polytechnic should provide AI training for lecturers, develop institutional policies, and invest in infrastructure such as internet connectivity and AI tools. Addressing resistance through awareness programs will encourage AI integration in teaching and learning.
2. The institution should seek funding from government and private sectors, collaborate with AI experts, and integrate AI courses into the curriculum. Clear policies, technical support, and ethical guidelines will help address concerns and facilitate smooth adoption.
3. AI-driven projects, business incubators, and mentorship programs should be introduced to equip students with practical skills. Expanding AI applications in business planning, decision-making, and digital entrepreneurship will enhance their readiness for the evolving business landscape.

REFERENCES

Abubakar, A., Onasanya, S. A., & Ibrahim, M. (2024). Student perspectives on AI integration in pedagogical practices within Nigerian tertiary institutions. *Journal of Educational Technology and Innovation, 12*(3), 45-62.

Chen, L., Zhang, W., & Huang, X. (2024). Artificial intelligence in business education: Enhancing learning and entrepreneurship. *International Journal of Business and Technology, 15*(1), 78-95.

Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). Sage Publications.

Eteng-Uket, E., & Effiom, A. (2024). Higher education students' attitudes toward AI-based educational interventions for learning. *African Journal of Educational Research, 9*(2), 115-132.

Efuetanu, D. (2024). The impact of AI training programs on entrepreneurship skills development among Nigerian university students. *Journal of Entrepreneurship and Digital Transformation, 8*(1), 59-77.

Fishbein, M., & Ajzen, I. (1975). Belief, attitude, intention, and behavior: An introduction to theory and research. Addison-Wesley.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2019). How to design and evaluate research in education (10th ed.). McGraw-Hill.

Kothari, C. R. (2004). Research methodology: Methods and techniques (2nd ed.). New Age Int.

Kuratko, D. F., & Hornsby, J. S. (2023). Entrepreneurship education and economic development: Building an innovative ecosystem. *Entrepreneurship Research Journal, 11*(4), 231-245.

OECD. (2024). Fostering entrepreneurship through education: Policies and practices for innovation-driven economies. Organisation for Economic Co-operation and Development.

Okeseeyin, J. (2024). The role of AI in supporting entrepreneurial activities among business students in Nigerian higher education institutions. *Journal of Business Innovation, 7*(1), 98-112.

Singh, R., & Patel, M. (2023). The role of artificial intelligence in modern business education. *Journal of Business and Technology Education, 14*(2), 67-81.

Ufondu, P., & Obi, K. (2024). Integration of AI, data analytics, and digital marketing in Nigerian business education curricula. *Nigerian Journal of Business and Technology, 6*(1), 23-41.

Wang, H., & Lee, J. (2024). Challenges and opportunities in AI-driven business education. *Technology and Education Review, 19*(1), 44-60.

SUB-THEME 11
HOME SCIENCE MANAGEMENT TECHNOLOGY

INVESTIGATING BENEFITS AND CHALLENGES OF FOOD STORAGE PATTERNS PRACTICED BY HOME MAKERS IN ONDO WEST LOCAL GOVERNMENT AREA OF ONDO STATE

[1]Bello, M., [2]Olarewaju, C.A, Adeyanju, B. E.& [3]Folorunsho F. E.
[1,2,3] Home Economics Department, Adeyemi Federal University of Education, Ondo
Corresponding Author: bellomonsurat01@gmail.com; Phone number: +234 8060228181

Abstract

The primary objective of this study was to examine the benefits and challenges associated with food storage patterns employed by homemakers in the Ondo West Local Government Area of Ondo State. Specifically, four objectives and research questions guided the study. A descriptive research design was used for the study. Convenience and purposive sampling techniques were used to select 130 respondents (homemakers) for this study. Findings of the revealed that some of the storage patterns practiced by home-makers include heating of grains in the sun before keeping in air tight containers, such as mud silos, earthen pots, air tight guards above ground among others, while for yam storage, barn built on an open ground, re-burying in trenches covered with plant materials among others. Findings also revealed that some of the challenges encountered in different food storage patterns include climatic changes, such as prolonged heat, and droughts, among others. Also, increased demands of modern society have necessitated a modern storage system. It was therefore recommended that the government, policymakers, and researchers make available strategies, policies, and designs of storage structures for grains and tubers.

Keywords: Challenges, Food, Home-Makers, Storage Patterns,

Introduction

Food is any substance consumed to provide nutritional support for an organism. Food can be of plant, animal, or fungal origin, and contains essential nutrients, such as carbohydrates, fats, proteins, vitamins, or minerals. The substance is ingested by an organism and assimilated by the organism's cells to provide energy, maintain life, or stimulate growth (Metych, 2022). However, due to post-harvest losses resulting from improper storage, many of these foods are lost, leading to waste, quality deterioration, wasted effort, time lost, and food insecurity (Sawicka, 2022).

Food storage allows food to be eaten for some time (typically weeks to months) after harvest rather than immediately (Khan *et al.,* 2016). It is both a traditional domestic skill and, in the form of food logistics, an important industrial and commercial activity. Significant food losses occur due to inadequate storage conditions. Food is stored by almost every human society and by many animals. Storing of food has several main purposes such as Storage of harvested and processed plant and animals food products for distribution to consumers, enabling a better balanced diet throughout the year, Reducing food waste by preserving unused or uneaten food for later use, Preserving pantry food, such as spices or dry ingredients like rice and flour, for eventual use in cooking, Preparedness for catastrophes, emergencies and periods of food scarcity or famine, (FAO, 2019). It is crucial to ensure appropriate storage of the food items in other to maintain food safety, minimize food wastage, and in all ensuring food security, to align with

the Sustainable Development Goal 2 (SDG 2) which aims to achieve zero hunger through access to safe, nutritious, and sufficient food for all, aimed at eliminating hunger by 2030 (Adeyeye, (2017); Radhika, (2021).

Food storage practices are important measures taken by homemakers to manage household food, minimize food wastage, prevent foodborne illness, and ensure household food security. The duty of food management and storage is that of the homemakers who use different food storage patterns that can prevent food spoilage, impact food quality, and ensure food during storage (Afriyie, 2022). Homemakers use various storage patterns for yam and grain storage to ensure adequate food security, prevent spoilage due to post-harvest losses. Some of these storage practices include: underground storage for yams, huts with shelves, barns built on open ground, bamboo enclosures, piling on dried mulch on heaps, re-burying in trenches covered with plant materials, storage in boxes lined with moist sawdust, piling on raised platforms (Umogbai, 2013), while grains are stored in solid wall bins, cribs, platforms, granaries, Heating of grains in the sun helps to reduce the moisture content before keeping in air-tight container. Exposure to open fireplaces for firewood heat penetration, unshelled maize cobs, and other unthreshed cereals is tied to the walls to prevent insect invasion (Mobolade, *et al.,* 2019)

These storage patterns can be influenced by various factors such as socioeconomic factors, cultural practices. Storage facility availability, knowledge of food safety and storage practices (Kilonzo-Nthenge *et al.,* 2018). Others are methods of handling food from farms and markets, climatic changes, lack of education and training in new food storage techniques, and exorbitant prices of some storage facilities (Afriyie *et al.,* 2022)

The judicious and proper food storage practices are of utmost importance in the prevention of outbreaks of foodborne illness, that is, the occurrence of disease or illness resulting from the consumption of contaminated food, food waste as a result of improper storage practices, which can result in economic loss and environmental degradation. Proper food storage practices preserve both the nutritional and aesthetic value of food, reduce money spent on groceries, and prepare for catastrophes, emergencies, periods of scarcity, and ensure availability all year round (Marshal, 2021; Dimond, 2012). Hence, appropriate and effective food storage can reduce food waste, thereby saving household income, preventing foodborne illness, promoting food safety, and ensuring availability of the best quality at all times (Markovic, 2023; Kendal & Dimond, 2012).

> *Although, food storage is essential, there are a lot of challenges faced by homemakers to achieve proper food storage practices, which include inadequate knowledge of proper storage practices, limited storage facilities, lack of food safety knowledge, and influence of cultural or traditional practices, among others. Having adequate knowledge of the benefits and challenges of food storage patterns practiced by homemakers is germane for developing targeted interventional programmers, training, and educational programs that promote safe, economical, and efficient food storage practices (Food Health System Advisory, 2018).*

This study aimed to investigate the benefits and challenges of food storage patterns practiced by homemakers. The findings of this study will contribute meaningfully to the development

of evidence-based guidelines and recommendations for improving food storage practices, thus promoting reduced food waste, food safety, and it will reduce environmental degradation.

Purpose of the Study

The main objective of the study was to investigate the benefits and challenges of food storage patterns practiced by home makers in Ondo West Local Government Area of Ondo State. Specifically, the study:

i. documented the different food storage patterns practiced by home makers in Ondo West Local Government Area of Ondo State
ii. examined the benefits of different food storage patterns practiced by home makers in Ondo West Local Government Area of Ondo State.
iii. investigated the challenges of different food storage patterns practiced by home makers in Ondo West Local Government Area of Ondo State

Research Question

i. What are the different food storage patterns practiced by home makers in Ondo West Local Government Area of Ondo State?
ii. What are the benefits of different food storage patterns practiced by home makers in Ondo West Local Government Area of Ondo State?
iii. What are the challenges of different food storage patterns practiced by home makers in Ondo West Local Government Area of Ondo State?

Methodology

Research Design

Descriptive design was used for this study. This design was adopted because descriptive studies make no attempt to manipulate variables, and it is concerned with describing and interpreting existing relationships, attitude practical processes and tends to compare variables (Taherdoost, 2021).

Area of the Study

The study was carried out in Ondo West Local Government Area of Ondo State. Ondo West is a Local Government Area in Ondo State, Nigeria. The major staple of the people in this community is roots and tubers as well as grain.

Population of the Study

The population of the study comprised of all the women in Ondo West Local Government Area of Ondo State. According to National population commission of Nigeria (2006), the total number of women in Ondo city from the Population change from 2000 to 2015 is 131,452

Sample and Sampling Techniques

The size of the study consisted of one hundred and thirty(130) respondents. Eleven (11) respondents were selected from eleven wards while nine (9) respondents were selected from one of the wards in Ondo West Local Government. Convenience and purposive sampling techniques were used to select respondents that constituted the sample for the study.

Research Instrument

A 4-pointlikert scale self-structured questionnaire was used to carry out the study based on the research questions. The questionnaire was divided into five sections A, B, C, and D Section A consisted of the demographic data of the respondents while section B, C, D, and E was drawn to obtain information on the different food storage patterns, benefits, and challenges of different food storage patterns practiced by home makers in Ondo West Local Government Area of Ondo State.

Validity of Instrument

The instrument was validated by the project supervisor and two (2) other lecturers from the Department of Home Economics, Adeyemi College of Education, Ondo to ensure face and content validity. Their corrections, observations, suggestions and comments was used to make constructive corrections in the final copy of the instrument.

Reliability of Instrument

Test re-test method was used to determine the internal consistency and level of precision of the instrument. Fifteen (15) copies of the questionnaire was administered and read ministered to same set of respondents outside the research area. The period between the first and the second administration were two weeks. The first and second responses instances were correlated. The reliability index was estimated using Cronbach alpha and a reliability of co-efficient (r) of 0.915 was obtained. The instrument was therefore considered reliable.

Method of data collection

One hundred and thirty (130) Copies of the questionnaire were administered personally to the respondents in various household visited and the filled copies of questionnaire were collected immediately to avoid loss in transit.

Data Analyses

The responses to the questionnaire items was collated and analyzed using standard deviation, mean (x) and t-test. The mean of the questionnaire will be interpreted based on the statistical real limits of numbers as follows. Strongly agree (SA) = 4, Agreed (A) = 3, Disagreed (D) = 2, Strongly Disagreed (SD) = 1. A cut-off point (COP) will be used to determine accepted or rejected items. The formular for attaining the cut-off point was totaling by the nominal values divided by the number of nominal values. That is,

$$\text{COP} = \frac{4+3+2+1}{4} = \frac{10}{4} = 2.50$$

Decision Rule: Any mean of 2.50 and above was considered as agreed, while any mean below 2.50 was considered as disagreed.

The null hypotheses was tested using t-test statistics at the probability of 0.05 level of significant at relevant degree of freedom with the use of statistical package for social sciences (SPSS) version 20. The null hypotheses was acceptable at the probability value of calculated 't' greater than 0.05 level of significance.

Result and Data analyses

Research Question 1: What are the different food storage patterns practiced by home makers in Ondo West Local Government Area of Ondo State?

Table 1: Mean and standard deviation of responses of the respondents on different food storage patterns practiced by homemakers

			N=129	C=2.50
S/N	**Different food storage patterns practiced by homemakers**	**Mean($\bar{x}$)**	**SD**	**Decision**
	GRAINS			
1	Heating of grains in the sun helps to reduce the moisture content before keeping in air air-tight container	3.87	.362	**Agreed**
2	Exposure to an open fireplace for heat of firewood to penetrate food products	3.69	.512	**Agreed**
3	Unshelled maize cobs and other unthreshed cereals are tied to the wall to prevent insect invasion.	3.66	.508	**Agreed**
4	Keeping in air-tight containers that are above the level ground helps in the preservation of food produced	3.53	.531	**Agreed**
5	The use of an underground pit	3.67	.533	**Agreed**
6	Metal silos are used for grain storage	3.61	.577	**Agreed**
7	Warehouses with raised platforms are used nowadays	3.63	.574	**Agreed**
8	Farm stores have been equally used	3.50	.651	**Agreed**
	Yams			
9	Storing of yam tubers in ban built on an open ground	3.53	.560	**Agreed**
10	Yam tubers can be piled up on a carpet of dried mulched in a heap.	3.43	.609	**Agreed**
11	Yams can be re-buried in trenches covered with plant materials	3.60	.580	**Agreed**
12	They can be stored in boxes lined with moist sawdust.	3.33	.794	**Agreed**

Key: N: Total number of respondents C= cut-off Point, ($\bar{x}$) = Mean responses of all respondents, SD = Standard Deviation

Table 1 shows the overall mean responses of all the items range from 3.50 to 3.87. this implies that the respondents agreed with all the items statement on different food storage patterns practiced by home makers in Ondo West Local Government Area of Ondo State because their mean was above the cut-off point 2.50.

Research Question 2: What are the benefits of different food storage patterns practiced by home makers in Ondo West Local Government Area of Ondo State?

Table 2: Mean and standard deviation of responses of respondents on the benefits of different food storage patterns practiced by homemakers.

	ITEMS	Mean($\bar{x}$)	SD	Decision
13	Ensuring the availability of food in all seasons	3.72	.500	**Agreed**
14	Food storage patterns can help prevent foodborne illness caused by harmful bacteria	3.55	.544	**Agreed**
15	Prepare for catastrophes, emergencies, and periods of food scarcity or famine	3.47	.531	**Agreed**
16	Proper food storage helps to preserve the nutritional value, color, and texture of the food product	3.53	.517	**Agreed**
17	Reduces the money spent on grocery	3.72	.559	**Agreed**

Key: N: Total number of respondents, C = cut-off Point, ($\bar{x}$) = Mean responses of all respondents, SD = Standard Deviation

Table 2 shows that the overall mean responses of all the items ranged from 3.47 to 3.72 this implies that the respondents agreed with all the items statement on the benefits of different food storage patterns practiced by home makers in Ondo West Local Government Area of Ondo State, because their mean was above the cut-off point of 2.50. The standard deviation of the responses ranged from 0.500 to 0.559 and was low. This indicates that the responses were clustered around the mean.

Research Question 3: What are the challenges of different food storage patterns practiced by homemakers in Ondo West Local Government Area of Ondo State?

Table 3: Mean and standard deviation of responses of respondents on the challenges of different food storage pattern practiced by home makers in Ondo West Local Government Area of Ondo State

S/N	ITEMS	Mean	SD	Decision
18	Method of handling the raw food from the farm/market to the home	3.69	.481	Agreed
19	Climatic changes such as prolong heat, food, droughts among others may increase the rate of food spoilage.	3.87	2.723	Agreed
20	Lack of education and training in new technologies, techniques, and agricultural products storage	3.44	.558	Agreed
21	Inability to comply food regulatory rules	3.55	.544	Agreed
22	Exorbitant prices of some storage facilities	3.47	.573	Agreed

Key: N: Total number of respondents C= cut-off Point, ($\bar{x}$) = Mean responses of all respondents , SD = Standard Deviation

Table 3 shows that the overall mean responses of all items ranged3.44 to 3.87.This implies that the respondents agreed with all the items statement on the challenges of different food storage patterns practiced by home makers in Ondo West Local Government Area of Ondo State because their mean was above the cut-off point of 2.50. The standard deviation of the responses ranged from 0.448 to 2.723 and was low. This indicates that the responses were clustered around the mean.

Discussion of the findings

Table 1 revealed that homemakers store yam tubers in a pile, on a carpet of dried mulch in a heap, re-burying them in trenches covered with plant materials. Some traditional storage methods for fresh yams include re-burying the roots in trenches covered with plant material and soil, piling the roots in heaps on wet sawdust. The result revealed that heating of grains in the sun helps to reduce moisture content before keeping in air air-tight container, also exposure to an open fireplace for the heat of firewood to penetrate food products, storage of grains in cribs and granaries are practiced by homemakers. The findings on the storage practices by homemakers in this study are also in line with the findings of (Umogbai, (2013); and Mobolade *et al.,* (2019) on the storage methods of yam and grains respectively. This is similar to the findings of Arun et al. (2017), who were of the view that a substantial amount of food grains is being damaged after harvest due to a lack of adequate storage and processing facilities. Moreover, significant agricultural production could be impacted due to variations in periodicity and intensity of climatic events like floods, droughts, temperature, and rainfall patterns.

Table 2 shows the overall mean and standard deviation of the benefits of different food storage patterns practiced by homemakers. Some of the benefits or importance of food storage patterns is that they help to preserve food items for later consumption. One of the key benefits of food storage is that it prevents food from spoiling, which can occur when food is exposed to air, moisture, and bacteria. When food spoils, it can become unsafe to eat and may cause foodborne illnesses. The spoilage of these food types of storage has resulted in the starvation of millions of people worldwide, including people who suffer from undernourishment. All the storage practices and methods reviewed in this study are comparatively cheaper and constructed with readily available local materials, are eco-friendly, and impart a considerably high shelf life to stored food grains by effectively reducing or suppressing insect infestation. Another benefit of food storage is that it can help prevent the loss of food nutrients. Many nutrients, such as vitamins and minerals, are sensitive to light, heat, and air exposure, and can degrade quickly if food is not stored properly. The findings of this study are in line with the findings of Marshal (2021) & Dimond,& Kendall, (2012).

Table 3 shows responses on the challenges of different food storage patterns practiced by home makers in Ondo West Local Government Area of Ondo State. The responses indicate challenges such as Inadequate availability of storage facilities, climatic changes such as prolong heat, food, droughts among others may increase the rate of food spoilage and lack of education training in new technologies techniques, and agricultural products storage were considered as the challenges encountered by homemakers. The finding of this study on the challenges of food storage practices by homemakers concur with the report of Kilonzo-Nthenge *et al.,* (2018), who reported that storage patterns can be influenced by various factors such as socioeconomic factors, cultural practices. Storage facility availability, knowledge of

food safety and storage practices. It was equally reported factors such as methods of handling food from farms and markets, climatic changes, lack of education and training in new food storage techniques, and exorbitant prices of some storage facilities (Afriyie *et al.*, 2022).

Conclusion

The traditional storage methods/traditional storage structures patterns used by homemakers have their drawbacks, such as post-harvest losses, food quality deterioration, and hence food wastage. Therefore, there is a need to adopt better storage methods in order to reduce food waste, maintain product quality, and thus improve food security in various homes, thus ensuring global security.

Recommendation

Based on the research findings, it is recommended that

1. Implementation of capacity–building programs should be implemented to educate homemakers on the best storage practices for their yams and grains
2. Provision of affordable innovative storage technologies to small-scale farmers and homemakers to improve food storage practices
3. Government and policymakers should provide a policy to support research, storage infrastructures, training, and extension services to enhance food security and food waste reduction

REFERENCES

Adeyeye, S.A. (2017). The role of food processing and appropriate storage technologies in ensuring food security and food availability in Africa. Nutrition and Food Science, 47 (1). 122–139 | 10.1108/NFS-03-2016-0037.

Afriyie, E., Gatzweiler, F., Zurek, M., Asem, F. E., Ahiakpa, J. K., Okpattah, B., Aidoo, E. K., & Zhu, G. (2022). Determinants of Household-Level Food Storage Practices and Outcomes on Food Safety and Security in Accra, Ghana. *Foods*, *11*(20), 3266. https://doi.org/10.3390/foods11203266

Dimond, N.; Kendall, P. *Food Storage for Safety and Quality*; Colorado State University: Fort Collins, CO, USA, 2012; Available online: http://www.ext.colostate.edu/pubs/foodnut/09310.pdf (accessed on 16 June 2025).

FAO, (2019). The State of Food Insecurity in the World 2015. Meeting the 2015 International Hunger Targets: Taking Stock of Uneven Progress, FAO in Conjunction with IFAD and WFP, Rome.

Food Health System Advisory (2018). Challenges of Food Storage in Nigeria and Possible Solutions https:// fhsafrica.org/2018/11/01/ Challenges -of- Food -Storage -in -Nigeria -and -Possible Solutions –

Khan, F., Bhat, S.A., &Narayan, S. (2016). Storage method for fruits and vegetables. https://www.researchgate.net/publication/316974334

Metych, M. (2022). Global food security. https://www.britanical.com/typical/food.

Markovic, D. (2023). Food handling and storage: Best practices for keeping your food safe and fresh. https://weiseinkake.com/food-handling-and-storage

Marshall, M. (2021). Prepared for a crisis and the unexpected: Managing everyday eventualities through food storage practices. *Food Cult. Soc. 2021*, 1–26. [Google Scholar] [CrossRef]

Metych, M. (2022). Global food security. https://www.britannica.com/topic/food

Mobolade, A. J., Bunindro, N., Sahoo, D., & Rajashekar, Y. (2019). Traditional methods of food grains preservation and storage in Nigeria and India. *Annals of Agricultural Sciences*, *64*(2), 196-205. https://doi.org/10.1016/j.aoas.2019.12.003

Radihka, K. (2021). Food safety in storage and transportation. https://www.researchgate.net/publication/35307316/

Sawicka, B. (2020). Post-harvest losses of agricultural produce. Doi: 10.1007/978-3- 319-95675-6-40

Taherdoost, H. (2021). Date collection methods are tools for research: a step-by-step guide to chosen data collection techniques for academic and business research projects. International journal of research in management *(IJARM),* 10(1), 10-38

Umogbai, V. I. (2013) 'Design, Construction and Performance Evaluation of an Underground Storage Structure for Yam Tubers', International Journal of Scientific and Research Publications, 3(5), pp. 1–7.

IMPACT OF UTILIZING DIGITAL SKILLS IN AUTOMOBILE THROUGH AI FOR ECONOMIC DIVERSIFICATION IN TECHNOLOGY EDUCATION

Orie, Chukwulenwenwa John and Daniel Chukwulenwa Onyije
School of Secondary Education (Technical),
Federal College of Education (Technical) Omoku, Nigeria
*Corresponding author email: oriechukwulenwenwa@gmail.com

Abstract

This paper investigates the integration of digital skills and artificial intelligence (AI) in the automobile industry and its role in promoting economic diversification through technology education. The study was guided by two main objectives: (1) to examine the extent to which digital skills and AI are utilized in automobile technology education, and (2) to assess the impact of AI-based digital skills on students' employability and economic diversification. Two research questions were raised, and two null hypotheses were tested: $H_{0\ 1}$ – there is no significant relationship between the use of digital skills through AI and the enhancement of employability among technical education students; and $H_{0\ 2}$ – the integration of AI in automobile technology education does not significantly contribute to economic diversification in the technology sector. Data were collected through a structured questionnaire administered to a sample of 150 respondents comprising students, educators, and industry practitioners. The reliability of the instrument was confirmed using Cronbach's Alpha with a coefficient of 0.84, indicating high internal consistency. Data were analyzed using descriptive statistics and Pearson correlation through SPSS version 25. Findings revealed a significant positive relationship between the integration of AI-driven digital skills and increased employability, as well as a measurable contribution to economic diversification. The study recommends the inclusion of AI and digital competencies in technical curricula as a strategy for strengthening workforce readiness and national economic transformation.
Keywords: Digital Skills, Artificial Intelligence, Automobile Industry, Economic Diversification, Technology Education.

Introduction

The global economy is undergoing a transformation driven by digital technologies and intelligent systems. For nations like Nigeria and other developing economies seeking to diversify beyond resource dependency, the integration of **artificial intelligence (AI)** and **digital skills** into **technology education** presents a significant opportunity. The automobile sector, in particular, stands at the crossroads of traditional manufacturing and digital innovation. As vehicles become smarter and more autonomous, there is a growing demand for professionals equipped with competencies in **AI**, **machine learning**, **Internet of Things (IoT)**, and **robotics** (World Economic Forum, 2023; OECD, 2022). **Artificial Intelligence (AI)** refers to the simulation of human intelligence by machines and computer systems that are capable of performing tasks such as problem-solving, decision-making, and learning (Russell & Norvig, 2021). **Digital skills** encompass the abilities needed to use digital tools and systems to access, create, and communicate information effectively (UNESCO, 2023). These include basic ICT skills, digital communication, coding, data literacy, and the operation of AI-driven applications. **Automobile digital skills** specifically refer to the competencies

required to operate, diagnose, and maintain modern vehicles that incorporate digital technologies. These skills include the use of **On-Board Diagnostics (OBD-II)** systems, electric vehicle (EV) software management, **computer-aided design (CAD)** for automotive parts, and **sensor-based systems** for autonomous and semi-autonomous driving (SAE International, 2023). With the rise of smart vehicles and electric mobility, technicians and engineers must be proficient in both hardware and software aspects of vehicle systems (McKinsey & Company, 2023).

Technology education refers to the systematic teaching and learning of technology-related content and practices to develop knowledge, skills, and attitudes necessary for the application and development of technology. In the context of vocational and technical education, it includes hands-on training and instruction in engineering, mechanics, electronics, and digital innovation aimed at solving real-world problems (UNESCO-UNEVOC, 2022). When aligned with modern digital trends such as AI and automation, technology education becomes a driving force for innovation, employment, and industrial growth. By equipping students with AI-integrated digital skills relevant to the automobile sector, technology education can better prepare the workforce for global trends while enabling countries to achieve sustainable economic diversification. For economies historically dependent on oil and raw materials, transitioning to a digitally skilled and innovation-driven workforce is essential for resilience and inclusive development (Nwachukwu & Adebayo, 2023).

The integration of **digital skills** and **artificial intelligence (AI)** into **automobile technology education** is a relatively underexplored but increasingly vital area in the context of developing economies, particularly in Africa. The literature on this subject highlights several key themes: the evolving nature of the automobile industry, the critical need for advanced digital competencies, and the role of education in addressing labor market demands. The automobile industry has witnessed substantial technological advancements, particularly with the rise of AI, robotics, and automation (McKinsey & Company, 2023). AI has become integral to modern vehicle design, diagnostics, and manufacturing processes. Technologies such as **autonomous driving systems**, **smart diagnostics**, and **predictive maintenance** are rapidly transforming vehicle production and service sectors (SAE International, 2023). These advancements require automotive professionals who not only understand traditional mechanical systems but also possess skills in software engineering, machine learning, and data analysis (OECD, 2022).In response to these changes, many developed countries have incorporated digital technologies and AI into their automobile-related programs in technical and vocational education and training (TVET) institutions. However, in African countries, including Nigeria, there remains a significant gap in aligning educational curricula with the industry's technological needs. This gap leaves students underprepared for the job market, particularly in emerging fields such as **electric vehicles (EVs)** and **autonomous vehicle systems** (Nwachukwu & Adebayo, 2023).

The automobile industry has undergone significant transformation over the past few decades, driven by technological advancements that have reshaped vehicle design, manufacturing, and operational processes. At the heart of this transformation is the integration of **artificial intelligence (AI)** and **digital technologies**, which are revolutionizing not only the way vehicles are manufactured but also how they function, interact with drivers, and respond to real-time data. Historically, the automobile industry was dominated by manual labor and mechanical systems, but the introduction of **automation** and **computerization** in

manufacturing processes since the mid-20th century has led to increased production efficiency and reduced human error. With the rise of **robotics** and **programmable logic controllers (PLCs)**, car manufacturing processes became more streamlined, leading to the **mass production** of vehicles (Brynjolfsson & McAfee, 2014). However, the real breakthrough has come with the advent of **artificial intelligence (AI)**, which is now being incorporated across various facets of the automobile industry. In contemporary vehicle design and manufacturing, AI is leveraged to improve product quality, design accuracy, and production efficiency. **Machine learning algorithms** are now used to optimize design processes, allowing for faster prototyping and testing (Porsche, 2022). These technologies enable manufacturers to simulate different vehicle conditions and scenarios, enhancing the accuracy and safety of vehicle designs before they enter mass production. Moreover, AI-driven **predictive maintenance** systems are being integrated into both vehicle manufacturing and in-service maintenance. These systems can detect potential vehicle malfunctions or wear-and-tear long before they become critical issues, allowing manufacturers to prevent costly repairs and downtime (McKinsey & Company, 2023). Predictive maintenance also plays a pivotal role in **reducing operational costs** and ensuring the **longevity** of vehicles, providing a competitive edge for automotive manufacturers who adopt these technologies.

One of the most significant contributions of AI to the automobile industry is its role in the development of **autonomous vehicles** (AVs). Autonomous vehicles, also known as self-driving cars, rely heavily on AI to process data from an array of sensors and cameras, enabling them to make real-time decisions about navigation, speed, and safety. Companies like Tesla, Waymo, and BMW are at the forefront of developing fully autonomous vehicles powered by AI and **machine learning** algorithms (Liu *et al.,* 2022). These vehicles utilize **computer vision**, **natural language processing**, and **neural networks** to interpret their environment and safely operate without human intervention. As this technology continues to evolve, AI is expected to enhance vehicle safety by significantly reducing accidents caused by human error (PWC, 2023). Furthermore, AI has facilitated the development of **connected vehicles** — vehicles that communicate with each other and with external systems (such as traffic management systems) to improve safety and efficiency. **Vehicle-to-vehicle (V2V)** and **vehicle-to-infrastructure (V2I)** communication systems allow for real-time data exchange, optimizing traffic flow and enhancing overall road safety (Liu *et al.,* 2022).

AI is also being integrated into vehicle performance and user experience systems. Smart features such as **adaptive cruise control**, **collision avoidance**, **voice recognition systems**, and **personalized driving experiences** are now common in many modern vehicles (Saab, 2021). AI systems in cars can analyze driver behavior and make real-time adjustments to improve comfort, efficiency, and safety. For example, AI-powered navigation systems provide real-time route optimization based on current traffic data, weather conditions, and historical driving patterns, offering a smoother and more efficient driving experience (McKinsey & Company, 2023). Moreover, AI plays a critical role in the integration of **electric vehicles (EVs)** into the broader automotive landscape. The transition from internal combustion engine (ICE) vehicles to electric propulsion requires significant changes in vehicle design, battery technology, and power management. AI-driven **energy management systems** in EVs optimize power usage, increase battery lifespan, and ensure efficient energy distribution across the vehicle's systems (Daimler, 2022).

While the integration of AI offers significant advantages, it also poses several challenges. The

development of **autonomous vehicles**, for example, faces technological and regulatory hurdles. Issues related to **data privacy**, **safety standards**, and **ethics in AI decision-making** need to be addressed before fully autonomous vehicles can become mainstream (Brynjolfsson & McAfee, 2014). Additionally, there are concerns about the impact of automation on jobs in the automotive sector, particularly among workers in traditional manufacturing roles, who may need to transition to more digitally-oriented positions (ILO, 2022). However, the potential benefits of AI in the automobile sector far outweigh the challenges. The AI-driven revolution in the automobile industry offers unprecedented opportunities for innovation, job creation, and economic diversification. For emerging economies like Nigeria, investing in **AI-integrated automobile education** and training programs could help develop a workforce equipped to meet the demands of a digital, automated future, ultimately contributing to broader economic diversification and industrial growth (OECD, 2022; Nwachukwu & Adebayo, 2023).

While the integration of digital and AI skills into **technical education** has been transformative in many developed nations, the adoption in African countries remains relatively slow (UNESCO-UNEVOC, 2022). Technical education institutions across Africa face multiple challenges, including outdated curricula, insufficient infrastructure, and a lack of trained educators (OECD, 2022). These barriers hinder the effective integration of cutting-edge digital technologies like AI into the classroom. As a result, students are not equipped with the necessary skills to meet the demands of the modern labor market. Some initiatives have been launched to bridge this gap. For example, the **African Development Bank** (AfDB) has supported programs designed to enhance digital skills in various sectors, including automobile technology (AfDB, 2023). However, these efforts remain fragmented, and there is still a need for a more coordinated approach to integrating AI and digital competencies into national educational frameworks.

The adoption of AI and digital technologies in education and industry has a direct impact on employability, as it aligns skill development with the evolving needs of the job market. In the automobile industry, the demand for professionals proficient in AI, machine learning, and data analytics has grown significantly. AI has improved vehicle safety, enhanced driving experiences, and streamlined manufacturing processes, thereby increasing the demand for workers with digital and technical skills (McKinsey & Company, 2023). Incorporating these skills into the education system helps bridge the gap between the qualifications of graduates and the requirements of the job market, ultimately contributing to higher employment rates and better job prospects for graduates (Nwachukwu & Adebayo, 2023). Furthermore, the adoption of AI in education and industry contributes to **economic diversification** by fostering innovation and reducing reliance on natural resources (OECD, 2022). The role of **digital skills** in modern education cannot be overstated, particularly as economies move toward greater reliance on technology. Digital skills enable individuals to effectively engage with technology, whether for personal or professional purposes. In the context of the automobile sector, digital literacy and AI knowledge are crucial for professionals to thrive in a world where **AI-powered systems** are revolutionizing vehicle performance and service operations (World Economic Forum, 2023). The development of such skills is also seen as a pathway to enhancing employability and improving economic diversification.

For African nations like Nigeria, the integration of AI and digital skills into technology education could play a pivotal role in **economic diversification**. Currently, Nigeria's

economy is heavily reliant on the oil and gas sector, with limited advancement in industries that leverage technological innovations such as **smart manufacturing** and **sustainable energy solutions** (World Bank, 2023). By shifting focus to digital and AI-driven industries, such nations can reduce their dependence on traditional sectors and build a competitive workforce in advanced fields such as automotive technology, information technology, and green energy (ILO, 2022).

Statement of the Problem

Despite the growing global shift toward artificial intelligence (AI) and digital technologies in the automobile sector, many institutions of higher learning and technical education in Nigeria and other African countries still lag in integrating these advancements into their curricula. This technological gap results in graduates who are ill-equipped to meet the evolving demands of modern automotive industries, where smart diagnostics, automation, and AI-driven systems are becoming standard (UNESCO-UNEVOC, 2022; McKinsey & Company, 2023). Furthermore, Nigeria's economy has remained overly dependent on crude oil, with insufficient diversification into sectors driven by technological innovation and skilled labor (World Bank, 2023). While developed economies are leveraging AI to transform education and industrial productivity, technical education in many parts of sub-Saharan Africa continues to emphasize outdated mechanical techniques with little exposure to digital competencies, reducing the employability of graduates and widening the skills gap (OECD, 2022; Nwachukwu & Adebayo, 2023).

This disconnection between technical education and technological innovation poses a serious challenge to economic sustainability and youth employment. Without urgent intervention to embed AI and digital literacy into automobile technology education, the nation risks producing a generation of technically trained but globally uncompetitive professionals. Therefore, this study seeks to explore the impact of utilizing digital skills through AI in the automobile sector and how this integration can drive economic diversification and enhance the relevance of technology education.

Aims and Objectives of the Study

This study was guided by the following objectives:

1. To examine the extent to which digital skills and AI are utilized in automobile technology education.
2. To assess the impact of AI-based digital skills on students' employability and economic diversification.

Research Questions

Based on the stated objectives, the study sought to answer the following research questions:

1. To what extent are digital skills and AI technologies integrated into automobile education in technical institutions?
2. What is the relationship between the use of digital skills through AI and employability in the automobile industry?

Research Hypotheses

The following null hypotheses were formulated and tested in the course of the study:

- **H_{01}**: There is no significant relationship between the use of digital skills through AI and the enhancement of employability among technical education students.
- **H_{02}**: The integration of AI in automobile technology education does not significantly contribute to economic diversification in the technology sector.

Methodology

This study employed a **quantitative research design** to investigate the impact of utilizing digital skills in the automobile sector through **artificial intelligence (AI)**, with a focus on how such integration influences **employability** and **economic diversification** in the context of technology education. The research aimed to explore the relationship between digital skills acquisition and the enhancement of employability among students in technical education institutions, as well as the role of AI in driving economic diversification in the automobile industry. The research adopted a **cross-sectional survey design** that was appropriate for examining the current state of digital skills utilization in the automobile sector and its influence on both education and economic outcomes. This approach enabled the researcher to collect data from a sample of respondents at a single point in time, providing a snapshot of the key variables involved in the study (Creswell, 2014). The design facilitated the measurement of the relationship between digital skills, AI integration, employability, and economic diversification. The target population for this study consisted of **students, educators, and practitioners** in the automobile and technology education sectors. Specifically, the sample was drawn from **technical education institutions** and **automobile industry professionals** within Nigeria. The focus on Nigeria is due to its significant potential for economic diversification, particularly in sectors like automobile technology, which could play a key role in moving away from oil dependence. A **stratified random sampling technique** was used to ensure that all relevant sub-groups (students, educators, and industry practitioners) were well-represented in the sample. The total sample size for the study was **150 respondents**, with 50 students, 50 educators, and 50 industry professionals. This sample size was determined based on the recommendations of Cochran (1977) for ensuring statistically reliable results, given the population size and desired level of precision.

The data for this study were collected using two primary instruments:

1. **Structured Questionnaire**: A comprehensive questionnaire was developed to gather quantitative data from students, educators, and industry practitioners regarding the use of AI in automobile technology education and its perceived impact on employability and economic diversification. The questionnaire consisted of closed-ended questions with Likert scale items, designed to measure attitudes, perceptions, and experiences related to the adoption of digital skills and AI in education and the industry.
2. **Interview Guide**: Although the study focused on quantitative analysis, a set of semi-structured interviews were conducted with a select number of industry professionals to provide additional insights into the challenges and opportunities of integrating AI in the automobile sector. These interviews helped to validate the findings from the quantitative data and provided a more holistic understanding of the issue.

The data collection process was carried out over a three-month period, with the survey distributed to the selected sample in both online and paper formats to accommodate respondents' preferences. **Informed consent** was obtained from all participants, ensuring they understood the purpose of the study and their right to confidentiality. Respondents were assured that their participation was voluntary and that their responses would be used solely for academic purposes. For the interviews, industry professionals were contacted via email or phone to schedule a convenient time for the interview. The interviews were conducted in a semi-structured format, allowing for open-ended responses that provided rich qualitative data. To ensure the reliability and validity of the instruments, the **Cronbach's Alpha** coefficient was calculated for the questionnaire. The instrument demonstrated high internal consistency, with a Cronbach's Alpha value of **0.84**, indicating that the items on the questionnaire were highly reliable. Furthermore, expert validation was conducted by consulting with professionals in the fields of automobile technology, AI, and education, ensuring that the instruments accurately measured the intended constructs. Data collected from the structured questionnaires were analyzed using **descriptive statistics** (such as means, frequencies, and percentages) to summarize the demographic characteristics of the sample and the responses to key survey items. **Pearson's correlation coefficient** was used to examine the relationships between the variables of interest (AI utilization, digital skills, employability, and economic diversification). This statistical technique was chosen due to its ability to determine the strength and direction of linear relationships between two continuous variables (Field, 2013).

The qualitative data from the semi-structured interviews were analyzed using **thematic analysis**, which involved identifying and analyzing patterns and themes within the interview transcripts. This allowed for the triangulation of the quantitative findings and provided deeper insights into the perceived impact of AI integration in the automobile sector.

Results

RQ1:*What is the relationship between the utilization of digital skills and employability among students in automobile technology programs?*

To answer RQ1, a Pearson’s correlation was conducted to examine the relationship between the self-reported **digital skills** of students and their perceived **employability**. The results are presented in Table 1 below.

Variable	Mean	Standard Deviation	Pearson’s Correlation (r)	p-value
Digital Skills (Students)	4.20	0.75	0.65	0.002
Employability (Students)	4.10	0.80		

The correlation between digital skills and employability among students was **positive and moderate (r = 0.65)**. This indicates that as students reported higher levels of digital skill acquisition, they also reported better employability prospects. The result was statistically significant with a p-value of **0.002**, suggesting that the relationship is unlikely due to chance.

RQ2: ***How does the integration of AI in automobile education affect the economic diversification of the automobile sector?***

A Pearson's correlation was also conducted to examine the relationship between **AI integration in automobile education** and **economic diversification** in the automobile sector. The findings are presented in Table 2.

Variable	Mean	Standard Deviation	Pearson's Correlation (r)	p-value
AI Integration (Educators)	3.95	0.80	0.72	0.001
Economic Diversification (Industry)	4.30	0.85		

The correlation between AI integration in education and economic diversification was **strong and positive (r = 0.72)**. This suggests that as AI is more widely integrated into automobile education programs, there is a greater perception of economic diversification in the automobile sector. The result was statistically significant with a p-value of **0.001**, confirming that AI adoption is likely to play a significant role in driving diversification in the sector.

Ho1: ***There is no significant relationship between digital skills and employability among students in automobile technology programs*.**

Hypothesis	Pearson's Correlation (r)	p-value	Decision
Ho1: Digital skills and employability are not related	0.65	0.002	**Rejected**

The correlation between digital skills and employability (r = 0.65, p = 0.002) was **positive and statistically significant**. This means that the null hypothesis (Ho1) is **rejected**. There is a significant relationship between the digital skills students acquire and their employability in the automobile sector. This finding suggests that students with higher digital competencies are more likely to gain employment.

Ho2: ***There is no significant relationship between AI integration in automobile education and economic diversification in the automobile sector.***

Hypothesis	Pearson's Correlation (r)	p-value	Decision
Ho2: AI integration and economic diversification are not related	0.72	0.001	**Rejected**

The correlation between AI integration in automobile education and economic diversification ($r = 0.72$, $p = 0.001$) was **positive and statistically significant**. As a result, the null hypothesis (Ho2) is **rejected**. This indicates that AI integration in automobile education is indeed positively related to the economic diversification of the automobile sector, suggesting that AI adoption is contributing to economic expansion and innovation in the industry.

Discussion

The results from RQ1 and Ho1 confirm the significant role of **digital skills** in enhancing the **employability** of students in automobile technology programs. The positive correlation ($r = 0.65$) indicates that as students improve their digital competencies, particularly in areas related to **AI and automation**, they become more competitive in the job market. The statistically significant p-value (0.002) reinforces the reliability of this relationship. This finding is consistent with the literature on digital skills, which highlights their growing importance in industries that are increasingly becoming technology-driven, such as the automobile sector (Brynjolfsson & McAfee, 2014). Students who are well-versed in emerging technologies such as AI and machine learning will likely possess the **skills required** to work in cutting-edge roles within the automobile industry, thereby enhancing their employability prospects (OECD, 2022). The results from RQ2 and Ho2 demonstrate a strong relationship between **AI integration** in automobile education and the **economic diversification** of the sector. The high positive correlation ($r = 0.72$) suggests that AI adoption in educational programs is seen as a driver of innovation in the automobile sector, helping to move the industry beyond traditional practices and into new, diverse avenues. The findings align with global trends where **AI technologies**—such as **autonomous vehicles**, **connected cars**, and **smart manufacturing**—are not only transforming product offerings but also opening up new markets and business models. These technologies are essential to economic diversification, particularly in countries like Nigeria, which are seeking to reduce dependence on oil and gas revenues (Liu *et al.*, 2022). The study highlights that the automobile sector, with the support of AI, could become a significant contributor to broader economic diversification strategies.

The findings underscore the importance of **updating curricula** in automobile technology programs to include **AI and digital skills**. Educational institutions must equip students with the tools necessary to meet the evolving demands of the industry. Given the **strong correlation** between AI integration in education and economic diversification, stakeholders in the automobile sector—such as automakers, policymakers, and educators—must collaborate to **foster AI-driven innovation**. Furthermore, industry professionals should play an active role in shaping educational programs, ensuring that the training provided aligns with the latest industry trends and technology. This partnership between education and industry is crucial to achieving **mutual benefits**, including higher employability rates for graduates and greater economic growth for the sector.

Conclusion

This study highlights the growing importance of **digital skills** and **AI technologies** in shaping the future of the automobile industry. By enhancing the employability of students and contributing to economic diversification, these factors are playing a key role in the transformation of the sector. The integration of AI in educational programs is not only improving students' career prospects but also aiding the broader economic diversification

efforts of nations seeking to reduce dependence on traditional industries like oil and gas. It is clear that a forward-looking approach to education and industry collaboration is essential for maximizing the benefits of these technological advancements.

Recommendations

1. **Curriculum Enhancement**: Educational institutions should incorporate **AI and digital skills training** into their automobile technology programs to ensure students are prepared for future industry demands.
2. **Industry-Education Partnerships**: The automobile industry and educational institutions should form stronger partnerships to ensure that curricula align with current technological trends, facilitating seamless transitions for graduates into the workforce.
3. **Policy Development**: Policymakers should support initiatives that encourage the adoption of **AI technologies** within the automobile sector, particularly in developing economies, to boost economic diversification.
4. **Student Skill Development**: Students should actively seek opportunities to gain proficiency in **AI and digital skills**, as these competencies are increasingly becoming vital for employment in the modern automobile sector.

References

AfDB. (2023). *Promoting Digital Skills for African Youth: Opportunities and Challenges*. African Development Bank.

Brynjolfsson, E., & McAfee, A. (2014). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. W.W. Norton & Company.

Brynjolfsson, E., & McAfee, A. (2014). *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*. W.W. Norton & Company.

Cochran, W. G. (1977). *Sampling Techniques* (3rd ed.). Wiley.

Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (4th ed.). Sage.

Daimler. (2022). *AI for Electric Vehicles: How Artificial Intelligence is Transforming Battery Management*. Daimler AG.

Field, A. (2013). *Discovering Statistics Using IBM SPSS Statistics* (4th ed.). Sage.

ILO. (2022). *Skills Development for the Future of Work*. International Labour Organization.

Liu, J., Zhang, D., & Yang, F. (2022). AI-driven autonomous vehicles: Opportunities and challenges. *Journal of Automotive Technology and Innovations, 8*(3), 112-130. https://doi.org/10.1016/j.jati.2022.03.003

Liu, J., Zhang, D., & Yang, F. (2022). *AI-Driven Autonomous Vehicles: Opportunities and Challenges*. Journal of Automotive Technology and Innovations, 8(3), 112-130.

McKinsey & Company. (2023). *The future of mobility is autonomous and intelligent*. McKinsey & Company.

Nwachukwu, P. O., & Adebayo, T. O. (2023). *Reimagining TVET in Africa: From Skills Gaps to Digital Inclusion*. Journal of African Development.

OECD. (2022). *AI and the Labour Market: Enhancing Skills and Employability*.

OECD. (2022). *Skills for jobs: Digital skills and competences in the automobile industry*. OECD Publishing. https://doi.org/10.1787/9789264444566-en

Porsche. (2022). *AI in Automotive Design and Production: Revolutionizing the Future of Cars*. Porsche AG.

PWC. (2023). *AI and the Future of Mobility: Transforming the Automobile Industry*. PricewaterhouseCoopers.

Russell, S. J., & Norvig, P. (2021). *Artificial Intelligence: A Modern Approach* (4th ed.). Pearson.
Saab, S. (2021). *AI in Automobile Safety and User Experience*. International Journal of Automotive Engineering, 14(1), 50-68.
SAE International. (2023). *Skills for the Future Automotive Workforce*.
UNESCO. (2023). *Digital Literacy and Inclusion in Technical Education*.
UNESCO-UNEVOC. (2022). *Transforming TVET for a Sustainable Future*.
World Bank. (2023). *Nigeria Economic Update: Driving Growth Through Human Capital*..
World Economic Forum. (2023). *Future of Jobs Report*.

ENHANCING ATTRACTIVENESS OF TECHNICAL EDUCATION DEGREE PROGRAMME AMONGST STUDENTS SEEKING ADMISSION INTO UNIVERSITIES IN RIVERS STATE

Ekeukwu Pureheart Ocebe-Tani-Dininye-Nkoma
Department of Vocational and Technology Education, Faculty of Education,
Rivers State University.
Email: Pureheart.ekeukwu1@ust.edu.ng (+2348136109793)

Abstract

The study examined strategies for enhancing the attractiveness of technical education degree programme among students seeking admission into universities in Rivers State. It adopted a descriptive survey design, with a sample size of 280 respondents, comprising 200 senior secondary school students and 80 first-year university students selected using census and convenience sampling techniques. Data were collected using a structured questionnaire titled *Enhancing Attractiveness of Technical Education Degree programme Amongst Students Seeking Admission into Universities in Rivers State Questionnaire (EATEDPASSAURS)*. The instrument was validated through face and content validity, and its reliability was established using the test-retest method, yielding a Cronbach's Alpha coefficient of 0.78. Responses were analyzed using mean, standard deviation, and Z-test at a 0.05 significance level. Findings revealed that improved awareness through career counseling, media campaigns, and parental sensitization plays a crucial role in increasing students' interest in technical education. Additionally, enhancing programme quality through modernized training facilities, increased practical training, industry collaboration, and updated curricula was identified as a key factor in making technical education more attractive. Furthermore, the study found that limited recognition of technical education degrees, lack of equal employment opportunities, and lower salary structures discourage students from enrolling in technical education programmes. Hypothesis testing indicated no significant difference in the responses of secondary school students and first-year university students regarding awareness, programme quality, and degree recognition, suggesting a shared understanding of the issues. The study underscores the need for policy reforms, improved funding, industry partnerships, and enhanced professional accreditation to boost the appeal of technical education degree programme. It concludes that strategic awareness initiatives, curriculum improvements, and increased recognition of technical education graduates are critical for increasing enrollment and developing a skilled workforce in Rivers State and beyond.

Keywords: Enhancing, Attractiveness, Technical Education, Degree programme, Students Seeking Admission into the University

Introduction

Attractiveness is the quality of being appealing or desirable. Attractiveness of Technical and Vocational education and training also mean the interest and appeal that students have in choosing TVET as their educational option (Asghari, 2023). It involves the ability of TVET programmes to elicit students' interest by offering engaging and relevant educational experiences that align with their career aspirations and practical skills needs. Technical and

Vocational Education and Training (TVET) provides practical and skill-based education, focusing on equipping students with hands-on experience and competencies needed for specific trades and professions. This approach ensures that graduates are job-ready, capable of contributing effectively to their chosen industries from day one. Gunbayi (2014), states that TVET encompasses a variety of learning opportunities that prepare individuals for specific trades, crafts, and careers at various levels, ranging from a trade, a craft, technician, or a professional position. TVET enhances employability, supports career advancement, and stimulates economic growth. Furthermore, it offers a viable alternative to traditional academic pathways, promoting inclusive education and providing opportunities for lifelong learning and professional development, crucial for a dynamic and resilient labor market. (Winch, 2019)

Technical and Vocational Education and Training (TVET) has its roots in the industrial revolution of the 18th and 19th centuries. As economies shifted from agrarian to industrial, the demand for skilled labour increased, prompting the establishment of vocational schools and apprenticeships. Early TVET initiatives focused on equipping individuals with practical skills for trades such as carpentry, metallurgy, and weaving. The Prussian model, developed in the 19th century, emphasized formal technical education and served as a prototype for many nations. By the early 20th century, TVET was recognized as essential for economic development and social mobility (Sifuna, 2020). The late 20th and early 21st centuries have seen TVET increasingly integrated into broader educational systems and lifelong learning frameworks. Modern TVET programmes emphasize competency-based education, digital literacy, and entrepreneurial skills, reflecting the needs of contemporary economies (Russo, et. al. 2019). The advent of globalization and the fourth industrial revolution have further highlighted the importance of TVET in preparing a flexible and skilled workforce. Today, TVET is recognized as a crucial component for sustainable development, with initiatives aimed at making it accessible, inclusive, and aligned with industry needs. Governments, international organizations, and private sectors continue to collaborate to enhance the quality and relevance of TVET globally (Okolie, Igwe & Elom, 2019).

In recent years, Nigeria has sought to modernize its TVET system to align with global standards and the demands of a rapidly changing economy. The introduction of competency-based education, digital literacy, and entrepreneurship into TVET curricula reflects this shift. Initiatives such as the National Vocational Qualifications Framework (NVQF) have been implemented to standardize and improve the quality of vocational training. Additionally, partnerships with private sector organizations and international bodies aim to enhance the relevance and accessibility of TVET in Nigeria. The government's Vision 2020 plan and the Economic Recovery and Growth Plan (ERGP) emphasize the critical role of TVET in achieving sustainable economic growth and development.

As students of secondary school approach, the end of their secondary education, they begin to consider their future career paths and the type of education that will best prepare them for success. This critical juncture involves evaluating various educational options, including university degrees, colleges, Polytechnics and Technical and Vocational Education and Trainings (TVET). The decision-making process by secondary school students regarding the educational path to pursue is influenced by their interests, strengths, and career aspirations. Additionally, factors such as the economic landscape and job market trends play a significant role. Most students are increasingly aware of how certain fields align with their personal goals and the demand for specific skills in the workforce, which shapes their choices for future education and career paths (Russo, et. al. 2019).

Many secondary school students are practically-minded students drawn to fields more inclined toward practical and hands-on learning environments. These fields are known for their dynamic and applied nature, offering students the opportunity to engage directly with the tools and techniques they will use in their future careers. This type of experiential learning is not only engaging but also provides a clear link between education and real-world applications. For most secondary school students, the prospect of entering fields with robust job prospects and the ability to make a meaningful impact is a strong motivator to pursue programmes in these areas that will make them skillful (Sam, 2023).

The choice for adopting TVET as an educational and career path for students starts from the secondary school. This includes the junior secondary school and the senior secondary school. At the junior secondary school, the student is exposed to basic and introductory technology subject that targets to arouse their interest and choice of TVET at this level the students are given pre-vocational orientation. After junior secondary school, those students that are not able to push further for secondary school may embark on skill trainings in terms of apprenticeship and other non-formal training programmes. At senior secondary school, students have the option of continuing studies in a vocational and technical secondary school with specialized curriculum tailored towards technical skills and vocational training. Presently in Nigeria, the National Policy on Education provides that every student in Senior Secondary School in Nigeria must offer a vocational trade subject in addition to their preferred field of studies (NPE, 2014). This was done to encourage participation in technical and vocational education.

After Secondary School, students can embark on technical and vocational education and training through a number of ways. One of such ways is through the vocational training centers. These centers have flexible admission criteria and offer certificate and diploma programmes. They play a crucial role in bridging the gap between basic education and the labor market by equipping students with industry-relevant skills and competencies (Muogahlu, & Ahmad, 2023). Apprenticeship schemes and informal sector trainings are other ways the secondary school student can engage in technical and vocational education and training. The Government from time to time through various agencies and ministries flags up initiatives and programmes aimed at skill acquisition and skill development. Also, apprenticeship and skill training programmes aimed at providing hands-on training and real-world experience in various trades are organized by communities, oil companies and non-governmental organizations. These programmes are often more accessible to students from economically disadvantaged backgrounds and members of host communities, offering them an alternative pathway to acquire skills and gainful employment.

Students after secondary school can progress their training and acquisition of technical education through seeking admission to study any of the trade courses that leads to a degree in technical and vocational education disciplines. Progression from earlier mentioned foundational TVET programmes to university-level technical education is a critical pathway for student's advancement from just being technical skilled person to becoming professionally trained industrial technical experts at the technologist level. The skills and knowledge acquired at the secondary and technical college levels serve as a strong foundation for advanced studies in technical fields ((Muogahlu, & Ahmad, 2023). Universities in Rivers State such as the Ignatius Ajuru University of Education, Rivers State University etc. offer various undergraduate and postgraduate programmes in technical education, engineering, and other related fields, providing a continuum of education that builds on the competencies developed through TVET.

Students who have completed vocational training or obtained diplomas from technical colleges can gain admission into these university programmes, sometimes with advanced standing, which allows them to complete their degrees in a shorter period. This progression not only enhances the students' technical expertise but also opens up greater career opportunities, including roles in management, research, and teaching within the technical and vocational education sector. As students weigh their options, the promise of gaining relevant skills, achieving financial independence, and contributing to economic development amongst others, the need for choosing TVET as their educational path becomes imperative, hence this study on enhancing attractiveness of technical education degree programme amongst students seeking admission into universities in Rivers State.

Statement of Problem

Technical Education degree programme should naturally be a popular choice for university study, as they provide a pathway to becoming a skilled, independent, and self-reliant worker. These programmes offer opportunities for advanced and professional studies in TVET, preparing individuals not only as masters of their trade but also as professional technology educators capable of transmitting these skills to others (NPE, 2014). Such promising prospects should ideally motivate students to pursue technical education degrees. Likewise, parents and guardians should readily encourage and inspire their wards to take interest in these programmes, recognizing the importance of skill acquisition in today's skills-driven economy.

Despite the promising potential associated with offering technical education degree programme, these programmes continue to grapple with poor enrollment rates and societal stigmatization indicating unattractiveness. Aldossari (2020), highlighted the high attrition rates among students in Technical and Vocational Education and Training (TVET) colleges, suggesting that students may feel disconnected or uncertain about the value and future of their studies. Further compounding the issue, Puyate (2017), expressed concerns over the persistently low enrollment levels in TVET programmes, indicating a broader challenge in appealing to prospective students. This pattern reflects deeper societal perceptions thereby calling for targeted interventions to raise the appeal and perceived value of TVET education.

Poor awareness of technical education degree programme and knowledge of their importance in skill development and employment has led most students to look down on the programme. Many secondary school students have never heard that a technical education programme exists to prepare students for advanced and professional studies in technology and skill development. Moses (2019) noted that many students are unaware of the opportunities in TVET, as most students hold the mindset that TVET is for those who could not do well academically or whose parents are poor. This lack of awareness leads these students to choose other courses of study, even those who have potential in technical fields. Mutungi (2023), observed that insufficient career information and guidance is a leading factor in poor enrollment in technical education programmes. Most students who expect hands-on training upon enrolling in technical education degree programme are often disappointed to discover

that the program relies on the same theoretical lectures as other fields, with the practical component of training missing. This unfortunate experience discourages them from recommending the programme to others, as they share with friends and family the lack of practical training in these institutions, dissuading others from applying to the programme (Nutassey & Newton, 2014). Consequently, the programme's actual quality does not meet expectations.

Additionally, the lack of regard for certificates issued to graduates of technical education degree programme in industrial works by most employers has deterred some students from enrolling. Many believe that technical education degrees are strictly teaching degrees rather than industrial and technical credentials. Some graduates of technical education degree programme who are employed in the industry are not placed on par with colleagues who hold other university degrees. Some are even denied positions as workshop technologists and teachers in polytechnics and colleges of technology, which they were actually trained and qualified to handle. This situation has led many students to opt for courses outside technical education in the university. In light of these issues, this study investigates ways to enhance the attractiveness of technical education degree programme among students seeking admission to universities in Rivers State.

Purpose of the Study

The aim of this study was to advance ways to enhance the attractiveness of technical education degree programme amongst students seeking admission into universities in Rivers State. Specially, the study sought to:

1. Investigate Improved awareness for enhancing the attractiveness of technical education degree programme amongst students seeking admission into universities in Rivers State
2. Explore Improved quality of program for enhancing the attractiveness of technical education degree programme amongst students seeking admission into universities in Rivers State
3. Examine improved recognition of technical education degree certificates for enhancing the attractiveness of technical education degree programme amongst students seeking admission into universities in Rivers State

Research Question

In order to give focus to this study, the following questions were posed:

1. What constitutes improved awareness for enhancing the attractiveness of technical education degree programme amongst students seeking admission into universities in Rivers State?
2. What characterizes improved quality of program for enhancing the attractiveness of technical education degree programme amongst students seeking admission into universities in Rivers State?
3. What defines improved recognition of technical education degree certificates for enhancing the attractiveness of technical education degree programme amongst students seeking admission into universities in Rivers State?

Hypotheses

The following null hypotheses were formulated for the study:

1. There is no significant difference between the mean responses of senior secondary class 3 students in Rivers State schools and level 100 students in public universities in Rivers State on improved awareness for enhancing the attractiveness of technical education degree programme amongst students seeking admission into universities in Rivers State
2. There is no significant difference between the mean responses of senior secondary class 3 students in Rivers State schools and level 100 students in public universities in Rivers State on improved quality of program for enhancing the attractiveness of technical education degree programme amongst students seeking admission into universities in Rivers State
3. There is no significant difference between the mean responses of senior secondary class 3 students in Rivers State schools and level 100 students in public universities in Rivers State on improved recognition of technical education degree certificates for enhancing the attractiveness of technical education degree programme amongst students seeking admission into universities in Rivers State

Methodology

The study adopts descriptive survey design. This design is fundamentally crucial because the study sort to understand and unravel those things that constituent improved awareness, improved quality of program and improved recognition of technical education degree programme certificate that when these applicants are properly inundated of them, they would not hesitate in making choice of technical education degree programme as their prefer course of study. The study was carried out in Rivers State, Nigeria and is focused in Port Harcourt Metropolis. Port Harcourt is the state capital of Rivers State and has all group of people in Rivers State, living in the city. The population of the study comprised of Senior Secondary School class three students in public secondary schools within Port Harcourt metropolis and year one students in the two universities in Rivers State where technical education degree programme are offered, and these universities are Rivers State University and Ignatius Ajuru University of Education. The sample for this study was 280 respondents (80 year one students from RSU and IAUE, and 200 SS3 students selected across 10 public Secondary schools within Port Harcourt Metropolis). Selection was done using Census and Convenience sampling technique respectively. Data was collected using a survey questionnaire titled Enhancing Attractiveness of Technical Education Degree programme Amongst Students Seeking Admission into Universities in Rivers State Questionnaire (EATEDPASSAURS). The questionnaire was drafted after Likert five-point rating scale of agreement (Strongly Agree SA=5, Agree A=4, Undecided U=3, Disagree=2, Strongly Disagree=1). The questionnaire items were validated using face and content value. Reliability for the instrument was established using test-retest method and the reliability coefficient of 0.83 was obtained using Cronch Bach Alpha analysis. The data gotten from the study was analyzed using SPSS-2023, mean and standard deviation was used to answer the research questions and Z-test was used to test the hypotheses at 0.05 level of significance. The decision rule was based on a

mean value of 3.00. Items with mean score equal and above 3.00 were taken to be agreement while items with mean score below 3.00 were taken to be a disagreement.

Results and Discussion

Research Question 1: What constitutes improved awareness for enhancing the attractiveness of technical education degree programme among students seeking admission into universities in Rivers State?

Table 1: Mean and Standard Deviation of Responses on Improved Awareness for Enhancing the Attractiveness of Technical Education Degree programme

S/N	Items on Improved Awareness	Senior Secondary Students (n=200)		Decision	Public University Students (n=80)		Decision
		$\bar{x}_1$	SD1		$\bar{x}_{12}$	SD2	
1	Inclusion of technical education career talks in secondary schools	4.25	0.80	Agreed	4.38	0.75	Agreed
2	Media campaigns on the benefits of technical education	4.20	0.85	Agreed	4.35	0.78	Agreed
3	Increased parental and community sensitization on technical education opportunities	4.30	0.79	Agreed	4.42	0.74	Agreed
4	Collaboration between secondary schools and universities offering technical education programmes	4.15	0.83	Agreed	4.28	0.77	Agreed
5	Showcasing success stories of technical education graduates	4.18	0.82	Agreed	4.31	0.76	Agreed
6	Inclusion of technical education information in secondary school career counseling	4.22	0.81	Agreed	4.36	0.78	Agreed
7	Government-organized workshops/seminars on technical education prospects	4.12	0.87	Agreed	4.29	0.79	Agreed
8	Use of social media platforms to promote technical education programmes	4.10	0.89	Agreed	4.26	0.81	Agreed
	Grand Mean	**4.19**		**Agreed**	**4.33**		**Agreed**

(Researchers' Field Data, 2024)

Data in Table 1 indicates that all items were agreed upon by both secondary school students and first-year university students as effective strategies for improving awareness of technical education degree programme. The mean responses for secondary school students ranged from 4.10 - 4.30, while public university students had mean scores between 4.26 - 4.42. The standard deviation values show consistency in responses, indicating a shared view that career

talks, media campaigns, parental sensitization, and showcasing success stories are critical for increasing awareness and promoting technical education programmes.

Research Question 2: What characterizes improved quality of programmes for enhancing the attractiveness of technical education degree programme among students seeking admission into universities in Rivers State?

Table 2: Mean and Standard Deviation of Responses on Improved Quality of Technical Education Programmes

S/N	Items on Improved Quality of Programmes	Senior Secondary Students (n=200)		Decision	Public University Students (n=80)		Decision
		$\bar{x}_1$	SD1		$\bar{x}_2$	SD2	
1	Availability of modern technical training equipment	4.32	0.78	Agreed	4.45	0.69	Agreed
2	Inclusion of more practical training sessions in technical education programmes	4.40	0.75	Agreed	4.52	0.66	Agreed
3	Upgrading technical education curriculum to meet industry standards	4.38	0.79	Agreed	4.50	0.72	Agreed
4	Regular workshops and hands-on experience with industry professionals	4.35	0.81	Agreed	4.47	0.73	Agreed
5	Improved funding and infrastructure for technical education faculties	4.28	0.84	Agreed	4.42	0.76	Agreed
6	Collaboration between universities staff and industries for internships and job placements	4.30	0.82	Agreed	4.44	0.75	Agreed
7	Recruitment of highly skilled lecturers and instructors with industry experience	4.20	0.86	Agreed	4.37	0.79	Agreed
8	Government policies that support and promote technical education programmes	4.15	0.88	Agreed	4.33	0.80	Agreed
	Grand Mean	**4.29**		**Agreed**	**4.43**		**Agreed**

(Researchers' Field Data, 2024)

Data in Table 2 reveals that all items were considered crucial for improving the quality of technical education programmes by both senior secondary school students and first-year university students. The mean scores for secondary school students ranged from 4.15 to 4.40, while public university students had mean scores between 4.33 and 4.52. The consistent standard deviation values indicate agreement on the importance of modern training facilities, increased practical training, industry collaboration, and improved funding as key elements in enhancing the attractiveness of technical education degree programme.

Research Question 3: What defines improved recognition of technical education degree certificates for enhancing the attractiveness of technical education degree programme among students seeking admission into universities in Rivers State?

Table 3: Mean and Standard Deviation of Responses on Improved Recognition of Technical Education Degree Certificates

S/N	Items on Improved Recognition of Technical Education Degree Certificates	Senior Secondary Students (n=200)		Decision	Public University Students (n=80)		Decision
		$\bar{x}_1$	SD1		$\bar{x}_2$	SD2	
1	Equal employment opportunities for technical education graduates alongside other university degree holders	4.35	0.79	Agreed	4.48	0.70	Agreed
2	Government policies ensuring industries recognize technical education degrees for recruitment	4.30	0.81	Agreed	4.44	0.72	Agreed
3	Increased acceptance of technical education graduates for managerial and leadership positions	4.25	0.83	Agreed	4.38	0.74	Agreed
4	Encouraging industries to provide structured career growth paths for technical education graduates	4.28	0.82	Agreed	4.41	0.73	Agreed
5	Improved salary structure and benefits for technical education graduates in line with industry standards	4.22	0.86	Agreed	4.36	0.78	Agreed
6	Establishing technical education certification equivalency with other professions qualifications	4.18	0.87	Agreed	4.32	0.79	Agreed
7	Increased involvement of professional bodies in certifying technical education graduates	4.15	0.88	Agreed	4.30	0.80	Agreed
8	NUC projection of technical education degree programmeme and certificates awarded as professional technical certificate for industrial work engagements and not only a teaching degree.	4.10	0.90	Agreed	4.26	0.81	Agreed
	Grand Mean	**4.22**		**Agreed**	**4.36**		**Agreed**

(Researchers' Field Data, 2024)

Data in Table 3 indicates that all items were agreed upon by both secondary school students and first-year university students as necessary for improving the recognition of technical education degree certificates. The mean responses for senior secondary students ranged from

4.10 to 4.35, while university students had scores between 4.26 and 4.48. These findings highlight the need for equal employment opportunities, structured career growth, improved salary structures, and certification equivalency to enhance the recognition and value of technical education degrees. The relatively consistent standard deviation values suggest that both groups strongly agree on these factors as crucial steps toward making technical education programmes more attractive and viable for students considering university admissions.

Hypotheses

H_{01}: There is no significant difference between the mean responses of senior secondary school students and first-year university students on improved awareness for enhancing the attractiveness of technical education degree programme in Rivers State.

Table 4: Z-test Analysis on Improved Awareness for Enhancing the Attractiveness of Technical Education Degree programme

Respondents	N	$\bar{X}$	SD	Df	Z-Cal	Z-Crit	Sig Decision
Senior Secondary Students	200	4.19	0.83	278	1.45	1.96	Accept
University Students	80	4.34	0.76				

(Researchers' Field Data, 2024)

Table 4 shows that the calculated Z-value (Z-Cal) is 1.45, while the critical Z-value (Z-Crit) at df = 278 and a 0.05 significance level is 1.96. Since Z-Cal (1.45) < Z-Crit (1.96), the null hypothesis is accepted. This indicates that there is no significant difference between the mean responses of senior secondary school students and first-year university students regarding improved awareness for enhancing the attractiveness of technical education degree programme. The similarity in responses suggests that both groups recognize the importance of awareness initiatives such as career talks, media campaigns, and parental sensitization in promoting technical education.

H_{02}: There is no significant difference between the mean responses of senior secondary school students and first-year university students on improved quality of technical education programmes in Rivers State.

Table 5: Z-test Analysis on Improved Quality of Technical Education Programmes

Respondents	N	$\bar{X}$	SD	Df	Z-Cal	Z-Crit	Sig Decision
Senior Secondary Students	200	4.29	0.81	278	1.38	1.96	Accept
University Students	80	4.45	0.74				

(Researchers' Field Data, 2024)

Table 5 shows that the calculated Z-value (Z-Cal) is 1.38, while the critical Z-value (Z-Crit) at df = 278 and a 0.05 significance level is 1.96. Since Z-Cal (1.38) < Z-Crit (1.96), the null hypothesis is accepted. This means there is no significant difference between the mean responses of senior secondary school students and first-year university students regarding the importance e of improving technical education program quality. This agreement implies that both groups believe factors such as modern training equipment, increased practical training,

curriculum updates, and stronger industry collaboration are essential to making technical education programmes more attractive.

H_{03}: There is no significant difference between the mean responses of senior secondary school students and first-year university students on improved recognition of technical education degree certificates in Rivers State.

Table 6: Z-test Analysis on Improved Recognition of Technical Education Degree Certificates

Respondents	N	$\bar{X}$	SD	Df	Z-Cal	Z-Crit	Sig Decision
Senior Secondary Students	200	4.21	0.85	278	1.50	1.96	Accept
University Students	80	4.37	0.78				

(Researchers' Field Data, 2024)

Table 6 shows that the calculated Z-value (Z-Cal) is 1.50, while the critical Z-value (Z-Crit) at df = 278 and a 0.05 significance level is 1.96. Since Z-Cal (1.50) < Z-Crit (1.96), the null hypothesis is accepted. This implies that there is no significant difference between the mean responses of senior secondary school students and first-year university students regarding the need for improved recognition of technical education degree certificates. Both groups agree that equal employment opportunities, industry acceptance, structured career growth, and better salary structures are essential for enhancing the value of technical education degrees.

Discussion of Findings

The findings from Research Question 1 revealed that increased awareness plays a critical role in enhancing the attractiveness of technical education degree programme among students seeking university admission in Rivers State. The study showed that career talks, media campaigns, parental sensitization, collaboration between secondary schools and universities, and showcasing success stories of technical education graduates are essential in improving students' perceptions of technical education. Both secondary school students and first-year university students strongly agreed that a lack of exposure and inadequate career guidance contribute to the low enrollment in technical education programmes. This aligns with the study by Moses (2019), who noted that many students are unaware of the opportunities in TVET because of the widespread perception that it is only for individuals who perform poorly academically or come from low-income backgrounds. The agreement between the two respondent groups underscores the need for structured awareness initiatives at both secondary school and university levels to increase student interest in technical education as a viable career pathway.

The results in Research Question 2 emphasized that the quality of technical education programmes significantly impacts their attractiveness. The study found that modern training equipment, increased practical training, curriculum updates, and stronger industry collaborations are key to improving the appeal of technical education degree programme. Respondents agreed that the current system, which still relies heavily on theoretical instruction, fails to provide students with the hands-on skills needed to compete in the job market. This finding is supported by Nutassey, and Newton (2014), who observed that

students expecting hands-on training in technical education programmes are often disappointed when they encounter largely theoretical lectures, leading to dissatisfaction and negative feedback that discourages others from enrolling. The study highlights the importance of industry-driven training, internships, and modernized facilities in bridging the skills gap and making technical education more attractive to prospective students.

Findings from Research Question 3 established that lack of proper recognition for technical education degrees is a significant deterrent to enrollment. The study revealed that many employers prefer traditional university graduates over technical education degree holders, limiting employment opportunities and career growth for technical education graduates. Participants strongly agreed that equal employment opportunities, structured career growth, improved salary structures, and certification equivalency with other professional qualifications would significantly enhance the value of technical education degrees. This aligns with Asghari (2023), who found that the preference for traditional academic degrees over technical degrees remains a major factor discouraging students from enrolling in technical education programmes. The study's findings reinforce the need for policy reforms to ensure technical education graduates receive fair recognition in employment, professional certification, and career advancement opportunities. Addressing this issue would not only improve the attractiveness of technical education but also contribute to a more skilled and competitive workforce in Rivers State and beyond.

Conclusion

This study explored strategies for enhancing the attractiveness of technical education degree programme among students seeking admission into universities in Rivers State. The findings indicate that low awareness, poor program quality, and inadequate recognition of technical education degrees are the major factors discouraging student enrollment. Many secondary school students and even university undergraduates have limited knowledge of the opportunities available in technical education, which results in societal misconceptions that these programmes are inferior to traditional university courses. The study further revealed that effective career counseling, media campaigns, and advocacy programmes involving parents, educators, and industry professionals are critical in reshaping perceptions and increasing student interest in technical education. Without structured awareness programmes, many students may continue to overlook technical education as a viable path to professional success, despite its significant role in economic and workforce development.

Additionally, the study established that the quality of technical education programmes and recognition of technical degrees play crucial roles in student enrollment decisions. Outdated curricula, insufficient practical training, and a lack of modern learning facilities contribute to the negative perception that technical education is outdated and offers limited career prospects. To address this, universities must modernize their training facilities, update curricula to meet industry demands, and strengthen partnerships with industries for internships and job placements. Furthermore, technical education graduates often struggle with employment recognition and career progression, as many employers prioritize traditional academic degrees. To change this narrative, policies ensuring equal employment

opportunities, better salary structures, and increased industry recognition of technical education qualifications must be implemented. If these measures are adopted, technical education degree programme will become more appealing, leading to higher enrollment rates, a more skilled workforce, and long-term economic benefits for Rivers State and beyond.

Recommendations

Based on the findings of this study, the following recommendations are made:

1. Secondary schools should integrate career talks and counseling sessions focusing on the benefits of technical education during their morning devotions and social gatherings in the school
2. Government and private stakeholders should launch media campaigns to educate students and parents about technical education opportunities and support the school with training facilities
3. Universities should partner with local technical workshops outside the university community to ensure students receive industry-relevant skills.
4. Technical education curriculum should provide in the lecture and training timetable more practical training periods than lecture period, workshops sessions, and industry internships to improve student competence properly provided for in the lecture timetable.
5. Employers and industries should be encouraged to accord due recognition to technical education degrees certificates as a technical qualification for employment and promotions.
6. Government agencies and the departments offering technical education degree programme should organize community outreach programmes to change negative perceptions about technical education.
7. The National Universities Commission (NUC) and the Ministry of Education should reform policies to elevate the status of technical education in Nigeria with respect to recognition of the university technical education programme not only as a technical teacher programme but also as professional technical training programme.
8. The various professional bodies regulating the various industrial works in Nigeria should be made to include university technical education degree programme under their purview of professional supervision and accreditation to ensure that the trainings carried out meets the professional standards set out for that level of industrial and technical works.
9. Technical education degree programme must award degrees directly in the trade areas or specializations (e.g B.Sc Building Construction Industrial Technology Education) as frontline documentation in the certificate other than generic appendage of B.Sc in Industrial Technology Education, as this will aid visibility and first hand grab of the area of specialization which is the main catch for industry and employment.

Reference

Agyei-Boakye, I., Quayson, E., & Nutassey, K. N. (2014). The technical and vocational education and training (TVET) stigma in developing countries: The case of the furniture sector in Ghana.

Aldossari, A. S. (2020). Vision 2030 and reducing the stigma of vocational and technical training among Saudi Arabian students. *Empirical Research in Vocational Education and Training*, *12*(1), 3.

Amoamah, M. O., Ndom, E., Ampiaw, R. E., & Dadzie, J. (2017). Funding of Quality TVET Programmes in Tertiary Institutions: The Role of Business Development Units.

Arimonu, Maxwell. O. (2018), motivational strategies for attracting and retaining technical teachers in technical colleges in South-East, Nigeria. (unpublished student project research work)

Asghari, H. (2023). The Attractiveness of the Industrial Technology Program among Newly Arrived Students in Sweden. In *The 5th Crossing Boundaries Conference in Vocational Education and Training, Vocational Education and Training Transformations for Digital, Sustainable and Socially Fair Future, Kaunas, Lithuania, May 25-26, 2023.* (pp. 23-29). European Research Network Vocational Education and Training (VETNET); Vytautas Magnus University Education Academy.

Ayonmike, C. S. (2014). Factors affecting female participation in technical education programme: A study of Delta State University, Abraka. *Journal of education and human development*, *3*(3), 227-240.

Chukwu, D. U., Anaele, E. A., Omeje, H. O., & Ohanu, I. B. (2020). Assessing technical vocational education and training (TVET) labour market potentials: Comparison of conferees' opinions. *Journal of Technical Education and Training*, *12*(2), 12-23.

Grijpstra, D., & Papier, J. (2015). TVET teacher education in Africa. *Retrieved on*, *23*(09), 2018.

Gunbayi, I. (2014). Increasing the quality and attractiveness of vocational and technical secondary education and youth employment rate in Turkey: The project for strengthening vocational education and training (SVET). In *Qualities of Education in a Globalised World* (pp. 101-116). Rotterdam: SensePublishers.

Linten, M., Prustel, S., Woll, C., Roth, U., & Wurdak, A. (2014). Attractiveness of Vocational Education and Training: Permeability Successful School-to-Work Transitions and International Mobility. Selected Bibliography. *UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training*.

Lovšin, M. (2014). The (Un) Attractiveness of Vocational and Technical Education: Theoretical Background. *Center for Educational Policy Studies Journal*, *4*(1), 101-120.

Moses, K. M. (2019). Increasing Public Awareness on TVET Roles as A Government Strategy for Reducing Youth Unemployment. *Jurnal Pendidikan Sains Universitas Negeri Malang*, *7*(1), 478268.

Muogahlu, N., & Ahmad, A. B. (2023). Redesigning Technical Vocational Education and Training for Sustainable Economic Development in Nigeria. *Journal of Vocational Education Studies*, *6*(1), 96-110.

Mutungi, G. K. (2023). *Analysis of Factors Influencing Students' Decisions in Selecting Public Tvet Institutions in Nairobi County, Kenya* (Doctoral dissertation, KeMU).

National Policy on Education (2014). Ministry of Education, Federal Republic of Nigeria.

Nutassey, A. B. I. Q. E., & Newton, K. (2014). The technical and vocational education and training (TVET) stigma in developing countries the case of the furniture sector in Ghana. *Developing Country Studies*, *4*(26), 80-89.

Okolie, U. C., Igwe, P. A., & Elom, E. N. (2019). Improving graduate outcomes for technical colleges in Nigeria. *Australian Journal of Career Development*, *28*(1), 21-30.

Omar, M. K., Rauf, M. A., Ismail, N., Rashid, A. M., Puad, H. M., & Zakaria, A. (2020). Factors on deciding TVET for first choice educational journey among pre-secondary school student. *European Journal of Molecular & Clinical Medicine*, *7*(3), 609-627.

Onyeocha, E. I. E., & Ukwuoma, U. F. (2023). PROMOTION OF TERTIARY TECHNICAL AND VOCATIONAL EDUCATION AND TRAINING (TVET) IN NIGERIA: MATTERS ARISING. *UNIZIK Journal of Educational Research and Policy Studies*, *15*(3), 141-151.

Puyate, S. T. (2017). Strategies for Improving Female Students' Enrolment in Technical-Vocational Education and Training (TVET) Programmes in Rivers and Bayelsa States. *Journal of Education in Developing Areas*, *25*(1), 65-74.

Russo, G., Serafini, M., & Ranieri, A. (2019). Attractiveness is in the eye of the beholder. *Empirical Research in Vocational Education and Training*, *11*(1), 7.

Sam, T. H. O. M. A. S. (2023). *Students' perception and attitude towards technical and vocational education and training in the Western North Region* (Doctoral dissertation, University of Education, Winneba).

Sifuna, D. N. (2020). The dilemma of technical and vocational education (TVET) in Kenya. *Journal of Popular Education in Africa*, *4*(12), 4-22.

Simiyu, J. W. (2018). Factors that Influence the Attractiveness of a Technical and Vocational Education and Training Centre: A Case Study of a Technical Institute in Kenya. *Level 3*, *7*(1), 5.

Tripney, J., Hombrados, J., Newman, M., Hovish, K., Brown, C., Steinka-Fry, K., & Wilkey, E. (2013). Technical and vocational education and training (TVET) interventions to improve the employability and employment of young people in low-and middle-income countries: A systematic review. *Campbell systematic reviews*, *9*(1), 1-171.

Ugwoke, M. E., & Iluobe, I. O. (2022). ASSESSMENT OF CURRENCY OF CURRICULAR OF AGRO-BASED TRADES FOR TEACHING AND LEARNING OF 21ST

CENTURY SKILLS IN NIGERIAN TECHNICAL COLLEGES. *Journal of Educational Assessment in Africa, 15*, 105-122.

Winch, C. (201). The attractiveness of TVET. *Revisiting global trends in TVET: Reflections on theory and practice*, 86-122.

SUB-THEME 12
PRIVATE PUBLIC PARTNERSHIP

THE EFFECT OF ROAD TRANSPORTATION INFRASTRUCTURE ON ECONOMIC GROWTH IN NIGERIA

ALHASSAN YUNUSA ALKALI * HASSAN GIMBA SULEIMAN **
ADOGO SANDA GWALLO ***
Welding and Fabrication Mechanical Engineering * & **
Department of Building Technology ***
Minna Institute of Technology And Innovations
Phone Number: 08032091560 Email: yunusaaalhassan@gmail.com

Abstract: This paper examined the impact of road transportation on economic growth in Nigeria. Both primary and secondary data were used as sources of data. Probit model was used to analyze the primary data while multivariate model was used for analyzing the secondary data to determine the long run relationship between growth and road transportation in Nigeria. The result shows that the transport sector positive impact on the economic growth in Nigeria. Based on the findings, it was suggested that the government should come up with sustainable and implementable road development and maintenance policies that will ensure good access and flow in Nigeria. Also, economic growth in Nigeria depended on the level of good and accessible road transportation and facilitates business activities.

Keywords: Effect Road transportation, Infrastructure, economic growth and probit model.

Introduction

The relationship between transport infrastructure and economic growth has attracted a lot of research effort and attention from economists, policy makers and politicians since the early 1990s. (Kolo, 2022) said it remains essentially unclear whether the direction of causation is from transport infrastructure to economic growth or vice-versa or both. (Kessides, 1996) notes that one of the main shortcomings of research on the economic impact of transportation infrastructure is that it has so far not adequately accounted for simultaneity effects on which economic growth can lead to development of the transport system as well as result from it. Several previous studies could not confirm the direction of causation between the development of the transport sector and economic growth. In addition, most of these studies have typically relied on cross-sectional or panel data regressions. A general problem associated with such studies is that they implicitly impose or assume cross-sectional homogeneity on coefficients that in reality may vary across countries because of differences in geographical, institutional, social and economic structures. Hence, the overall results obtained from these regressions represent only an average relationship, which may or may not apply to individual countries in the sample (Bloch and Tang, 2003).

The adequacy of road transport infrastructure determines a country's success and another; failure in diversifying production, expanding trade, coping with population growth reducing poverty, or improving environmental conditions. A good road transport infrastructure raise productivity especially in the agricultural sector of the economy and lowers production costs. In Nigeria, the link between where the major production activities take place and where it is

needed for final consumption need good road transportation that will bridge the gap, although the precise linkages between infrastructure and development are still open to debate. However, according to the World Development Report, 1994 infrastructure capacity grows step by step with economic growth.

Good road infrastructure services helps the poor contribute to environments sustainability. Clean water and sanitation, non-polluting sources of power, safe disposal of solid waste, and better management of traffic in urban areas provide environmental benefits for all income groups. The urban poor often benefit most directly from good road infrastructure

services which mitigates standard of living conditions characteristic of concentrated settlements such as unsanitary conditions, hazardous emissions, and accident risks.

Integrated urban planning and transport policy can lead to more efficient use of both land and transport capacity with favourable environmental results. Expansion of transport infrastructure can reduce total pollution loads as congestion falls, average .Vehicle speeds rise, and routes are shortened. Road improvements can also encourage vehicle use and decrease emissions. Therefore, additions to infrastructure capacity are only part of the solution. Improved management of traffic and land use and promotion of non-motorized modes, cleaner fuels, and public transport are also important.

This paper is an attempt re-examine the impact of road transportation system on economic growth in Nigeria to achieve the objective above the study is structured into five sections, which are introduction, literature review/theoretical framework, the methodology, data presentation/analysis, and conclusions/recommendations.

Literature Review

The evidences of research on the subject matter of this study are mixed across countries, data and methodologies, with some of the findings having positive impact, while others find little or no significant growth effect of infrastructure. Empirical work by Asabe (2021) on the United States has provided evidence of a strong and positive relationship between public investment in infrastructure and growth over the period 1949-1985. He asserts that the decrease in public investment may be crucial in explaining the US economy‟s relatively poor economic performance between 1970s and 1990s. This finding has been confirmed in some subsequent studies, but challenged in others. For example, the World Bank‟s World Development Report (1994) finds a large range of empirical results on the importance of infrastructure for economic growth, with estimates ranging from no effect, to rates of return in excess of 100% per annum.

Using cross-country data, Easterly and Rebelo (1993) find a positive effect of investment in transport and communication on economic growth. Sanchez-Robles (1998) also find a positive impact of road length and electricity generating capacity in explaining subsequent economic growth. Asabe (2021) (2000) finds that the stock of public infrastructure capital is a significant determinant of aggregate total factor of productivity and that investments in public sector not only improve quality of life but also increase economic growth and returns

for private investments. The findings of Demetriades and Mamuneas (2000) indicate that public infrastructure capital has significant positive long-run effects on both output supply and input demands in 12 OECD countries. Bologi (2020) analyses the contribution of transport capital to growth for a sample of 38 Sub- Saharan African countries using both cross- sectional and panel data analysis. In both sample cases, the analysis concludes that transport capital has been a contributor to the economic progress of these countries. Result of Seethepalli (2008) also proves that infrastructure is important for promoting growth in East Asia.

The results obtained by Montolio and Solé-Ollé (2009) support the idea that productive public investment in road infrastructure has positively affected relative provincial productivity performance in Spain. In contrast, Tatom (1991; 1993), Holtz-Eakin and Schwartz (1995) and Garcia-Mila (1996) suggest that there is little evidence of an effect from infrastructure to economic growth in a panel of U.S. state level data, particularly when fixed effects are included. It is interesting to note that even though the relationship between transport infrastructure and economic growth has attracted a lot of research effort and attention from economists, policy makers and politicians in the early 1990s (Kolo, 2022), it remains essentially unclear whether the direction of causation is from transport infrastructure to economic growth or vice- versa or both. Kessides (1996) notes that one of the main shortcomings of research on the economic impact of transportation infrastructure is that it has so far not adequately accounted for simultaneity of effects-economic growth can lead to development of the transport system as well as result from it.

Mittnik and Neumann (2001) also establish that public investment has positive influence on GDP. However, there is no significant causal link running from GDP to public investment. Their results provide evidence for a complementary relationship between public and private investment. Using time series data for the US economy and cointegration analysis, Lau and Sin (1997) reject the endogenous growth model for the US economy. Looney (1997) analyses the effects of several types of public infrastructure in Pakistan and finds that public infrastructures have not been instigating private sector expansion but have been rather a response to the needs of the sector. Mamatzakis (2002) finds a positive effect of public infrastructure (ports, railways, roads, electricity and communications) on output and private capital productivity of the Greek industrial sector. He also finds that the causal relationship is from public infrastructure to productivity. Canning and Pedroni (2008) investigate the consequence of various types of infrastructure provision in a panel of countries. They show that while infrastructure does tend to cause long-run economic growth, there is substantial variation across countries.

Ashipala and Haimbodi (2003) look at the relationship between public investment and economic growth in South Africa, Botswana and Namibia using the VECM methodology. They find that the effect of public investment on growth is not significant however, it has the correct sign. On the other hand, private investment is shown to have a long run growth impact in South Africa and Namibia. However, they find evidence indicating a reverse

causality from GDP growth to public investment. The causality is negative in the case of Botswana suggesting that as the economy grows investment in public goods declines, which contradicts both the Keynesian theory and Wagner‟s law. Nurudeen and Usman (2010) use cointegration and error correction methods to analyze the relationship between government expenditure and economic growth in Nigeria. Their results reveal that government total capital expenditure, total recurrent expenditures, and government expenditure on education have negative effect on economic growth. On the contrary, rising government expenditure on transport and communication results to an increase in economic growth. Finally, Pradhan (2010) explores the nexus between transport infrastructure (road and rail), energy consumption and economic growth in India over the period 1970-2007. He finds evidence of unidirectional causality from transport infrastructure to economic growth.

Methodology

Econometrics methodology was employed in this study as the analytical tool for the examination of the relationship between road transport infrastructure and economic growth. Consequently, the Ordinary Least Squares method was adopted to investigate the long-run relationship between them. The model states that economic growth is a function of road transportation in GDP, capital utilization (CUR), government expenditure on road transportation (GENOT), and Exchange Rate (EXCHR).

To further examine the relationship, the study employed Johanson‟s Cointegration Test. The secondary data used were obtained from the World Bank Database, Central Bank of Nigeria Statistical Bulletin, National Bureau of Statistics, Global Development Finance Statistics and International Development Statistics.

Model Specification:

The model formulation of rooted in the theoretical framework as postulated by Bloch and Tang (2003), the model was specified as follows:

GDP = f(ROT, AIT, RAT)……(1)

Where the GDP is the gross domestic product in Nigeria, ROT is the amount of road transportation in the gross domestic product, AIT is the amount of air transportation in gross domestic product and RAT is the amount of rail transportation in gross domestic product in Nigeria. This model was used to establish the relationship between economic growth and transportation infrastructure in Nigeria.

Modification was done on the model in order to achieve the objective of the study as follows:

$$GDP = F(ROT, CUR, GENOT, EXCHR) \quad \ldots\ldots (2)$$

The model transformed by introducing the Logarithm form:

$$GDP = \beta_0 + \beta_1 ROT + \beta_2 CUR + \beta_3 GENOT + \beta_4 EXCHR + \varepsilon \quad \ldots\ldots (3)$$

From the model above the Gross Domestic Product is a function of the amount of Road Transportation in GDP, Capital Utilization (CUR), Government Expenditure on Road Transportation (GENOT), Exchange Rate (EXCHR) and the Error Term.

Taking the natural log of the variables in equation 3 we derive the equation 4 as follows:

$$InGDP = \alpha + \beta_1 InROT + \beta_2 InCUR + \beta_3 GENOT + \beta_4 EXCHR + \varepsilon \quad .....(4)$$

The a priori expectation of the model specified in equation 4 such that $\beta_1, \beta_2, \beta_3' and \beta_4 > 0$

Empirical Results, Interpretation and Analysis

A. Unit Root Tests:

The unit root test was conducted to ascertain the stationarity of the data before estimation using both the Augmented Dickey Fuller (ADF) and the Philips-Perron (PP). The results of the test presented in Table I show that all the variables included in the model are stationary at 1 percent level. Given the unit-root properties of the variables, we proceeded to conduct the co-integration test to ascertain the long-run relationship between transportation and economic growth.

Johansen Co-integration Test Results:

The Johansen co-integration test result in Table II shows the existence of two co-integrating equations at 5% significance level in the model. The hypothesis which states there is no long-run relationship between transportation infrastructure and economic growth is rejected at 5% significance level. This implies that there exists a long-run relationship between transportation infrastructure and economic growth in Nigeria.

	Likelihood	5 Percent	1 Percent	Hypothesized
Eigenvalue	Ratio	Critical Value	Critical Value	No. of CE(s)
0.753709	111.0280	82.49	90.45	None **
0.710742	70.39203	59.46	66.52	At most 1 **
0.362152	34.41942	39.89	45.58	At most 2
0.305066	21.37941	24.31	29.75	At most 3
0.225435	10.82518	12.53	16.31	At most 4
0.111151	3.417023	3.84	6.51	At most 5

**(**) denotes rejection of the hypothesis a 5 %(1%) significance level* L.R. test indicates 2 cointegrating equation(s) at 5% significance level

The Long Run Regression Results:

The table III below shows the estimation results of the equation used in the study, from the results the R-squared of 0.78 indicates that 78 percent variation in the dependent variable is accounted for by the estimated equation. This implies that 78 percent variation in the Gross Domestic Product in Nigeria is caused by the independent variables.

The Adjusted R-squared of 74 percent suggests that the model in used is fit in explanation the variation in GDP put in consideration the losses of degree of freedom cause by the number of independent variables, that is the independent variables are statistically significant in determining the total variation in Gross Domestic Product in Nigeria. The F- statistic suggest that the model employed in the study is statistically significant given the value as 18.45499 , meaning at 5 percent level of significant, the equation in use is statistically significant that means, useful in explaining a unit change in Gross Domestic Product in Nigeria.

From the result Road transportation contribution to Gross Domestic Product has a positive impact on Economic Growth in Nigeria, given its coefficient (0.209677) of the equation it is statistically significant at less than 5 percent level of significance and it is capable of determining the variation in economic growth in Nigeria. This implies a unit change in Road transportation contribution will cause 0.21 percent change in Gross Domestic Product in Nigeria.

The capital utilization from the model was seen to have a negative relationship on Gross Domestic Product in Nigeria but statistical insignificant in determining the variation in economic growth given its coefficient which is higher than 5 percent level of significance. This implies that in determining the impact of road transportation system on the Nigerian economic growth. Capital utilization is statistically insignificant in determining the changes in economic growth in Nigeria, but it has a negative effect on Gross Domestic Product in Nigeria.

The results shows that the Government Expenditure on Road Transportation (GENOT) is positively related to Gross Domestic Product in Nigeria and its coefficient suggests that Government Expenditure on Road Transportation (GENOT) is statistically significant at less than 5 percent level of significance in determining the variation in Gross Domestic Product in Nigeria. This implies that Government Expenditure on Road Transportation (GENOT) has a positive impact on economic growth in Nigeria and that Government Expenditure on Road Transportation (GENOT) can either increase the rate of economic growth in Nigeria or reduce the level of growth in Nigeria. From the result Government Expenditure on Road Transportation (GENOT) will is responsible for 0.160711 changes in Gross Domestic Product in Nigeria that is a unit change in Government Expenditure on Road Transportation (GENOT) will cause 0.161 percent change in Gross Domestic Product in Nigeria.

Exchange Rate (EXCHR) is found to be positively related to Gross Domestic Product in Nigeria that is having a positive impact on Gross Domestic Product in Nigeria, but statistically insignificant in explaining the variation in Gross Domestic Product in Nigeria given the value of its coefficient and the level of significance higher than 5 percent level of

significant. This implies that Exchange Rate (EXCHR) account for less or no variation in Gross Domestic Product in Nigeria that is its impact is less on the economic growth in Nigeria.

From the result the External Reserves (EXTR) was found to be positively related to Gross Domestic Product in Nigeria, and given the coefficient of 0.1447 and the level of significant it is statistically significant in accounting for the variation in Gross Domestic Product in Nigeria. This implies that External Reserves in Nigeria can improve road transportation which can translate to increase in economic growth in Nigeria. Also a unit change in external reserve we cause 0.1447 increases in Gross Domestic Product in Nigeria.

Summary of Major Findings and Policy Options

The analysis and the results from model estimation has clearly defined that there is a strong and positive relationship between road transportation and economic growth in Nigeria and also the results from the probity model shown that transportation infrastructure can improve the well-being of the citizens in Nigeria. From the results of the secondary data, it is clear that road transportation contribution to Gross Domestic Product in Nigeria has a great impact on the economic growth. This implies that transportation system can increase productivity and effective distribution at the long run increase the economic growth in country.

Government expenditure on transportation has a positive and a significant relationship on economic. The implication is that increase in government expenditure on transportation in Nigeria will increase the level of economic growth on the other hand reduction in government expenditure on transportation will cause decrease in the economic growth in Nigeria.

But over the years, government expenditure on transportation has been very poor and less attention has been shown by government.

Similarly, External Reserve was positively related to Gross Domestic Product in Nigeria and has a positive impact on economic growth. This is because external reserves can be used for expansion of capital project and can be used in road transport maintenance and for the construction of road facilities. If external reserves from the result can improve the economic growth in the country if the funds in the external reserves are well managed.

The following policies recommendations was made after the research findings

i. Government and its agencies like FERMA should come out with sustainable and implementable road development and maintenance policies that will ensure good access and good traffic flow on our roads across the nation.

ii. There is need to increase and encourage private participation in the provision of public transport services as mentioned earlier.

iii. The use of motorcycle as public mode of transportation in cities should be institutionalized since the users are constrained to use it in the absence of alternate. However, policies guiding the regulations and use of this mode should be formulated and

monitored so that its use would not affect negatively the commuters‟ mobility problems. Similarly, government should provide enabling environment that would guaranty efficient and adequate movement of vehicles in cities.

iv. The management of road transportation companies should make sure that the transport vehicles go through routine maintenance to reduce the rate of breakdown of transportation vehicle on the highway.

v. Secondly, the management as well computerizes the company as to monitor the speed limits on the driver. This will help to reduce the rate of road accidents and make the company to have goodwill and the management should also provide modern infrastructure and facilities to take adequate care of the commuters.

Conclusion

This research work was an attempt to examine the economic impact of road transportation system in Nigeria, seeing that all Nigerian government developmental agenda of the past and present leaders includes transportation development, especially road transportation as a tool for ensuring social well-being of its citizens. Some specific objectives were to examine the nature and state of road transportation system before, during and after independence in Nigeria.

Also to examine the various National policies and programme toward the revitalization of the road transportation system in Nigeria for economic growth and development, to investigate factors militating against the improvement and the development of road transportation in Nigeria and to examine the economic prospect of road transportation system if the policy of the present government transformation agenda is well managed and implemented.

The research findings suggests that road transportation has an impact in the economic development in Nigeria. From the result economic growth in Nigeria depended on the level of good and accessible road transportation and the level of road transport infrastructures that will complete the business activities and facilitate trade of Small and Medium scale Enterprises in Nigeria.

One of the challenges of road transportation system in Nigeria is poor funding and management of the facilities across the nation. From the research, it is noted that government attention to road transportation system and even the entire transportation sector is poor. Money meant for the maintenance of old projects and development of new projects are diverted for personal use. This has been the situation in Nigeria and most West Africa countries. For the road transport system to be revitalized, government should give more attention to the sector.

References

Asabe J (2021) DA (1989). “The public expenditure" Journal for Economics.

Bologi UB (2020). “Transport infrastructure and economic development: using dynamic panel estimates”. The Empirical Economics Letters, 5(1):30.

Demetriades PO, Mamuneas TP (2000). Inter temporal output and employment effect of public infrastructure capital: Evidence from 12 OECD Economics, 110(465):687-712

Easterly W, Rebelo S (1993). "Fiscal policy and economic growth", Journal of Monetary Economics, 32 :417-458.

Fernald GJ (1999). "Roads to prosperity? Assessing the link between public capital and Productivity", The American Economic Review, June:619-637

Garcia-Mila T, McGuire TJ, Porter RH (1996). The effect of public capital in state-level production functions reconsidered. The Review of Economics and Statistics, :177-180.

Kolo M (2022). Infrastructure Statement: A review essay. Journal of schools service in economic, 15:12-13

Holtz-Eakin D, Schwartz AE (1994). Infrastructure in a structural model of economic growth. NBER Working Paper No. W482K.

Kessides C (1996). "A review of infrastructure‟s impact on economic development", In: Batten D, Karlsson C (Eds.), Infrastructure and the Complexity of Economic Development, Chapter 12:213–230.

Lau SHP, Sin CY (1997). "Public infrastructure and economic growth: Time-Series Properties and Evidence"

Economic Record, 73(221):125–135. http://dx.doi.org/10.1111/j.1475-4932.1997.tb00986.x

Looney RE (1997). "Infrastructure and private sector investment in Pakistan". Journal of Asian Economics, 8(3):393-420. http://dx.doi.org/10.1016/S1049-0078(97)90046-4

Mamatzakis EC (2002). Public infrastructure and private output? An application to Greece. Journal of Economic Development, 27(2):143-160.

Mittnik S, Neumann T (2001). Dynamic effects of public investment: Vector autoregressive evidence from six industrialized countries. Empirical Economics, 26(2):429-446.

Nurudeen A, Usman A (2010). "Government expenditure and economic growth in Nigeria. 1970-2008: A disaggregated analysis". Business and Economics Journal. 2010(4):1-11.

Pradhan RP (2010). "Transport infrastructure, energy consumption and economic growth triangle in India: Cointegration and Causality Analysis". Journal of Sustainable Development. Vol. 3(2) :167-173.

Queiroz C, Gautam S (1992). "Road infrastructure and economic development-some diagnostic indicators". The World Bank Policy Research Working Paper no.921. [Online] Available:http://wwwwds.worldbank.org/servlet/ WDSContentServer/WDSP/IB/1999/04/28/000009265_3961004011323/Rendered/PDF/ multi_page.pdf.

Sanchez-Robles B (1998). "Infrastructure investment and growth: Some empirical evidence. Wiley Online Library, 16(1):98- 108.

Seethapalli K, Bramati MC, Veredes D (2008). How relevant is infrasturcture to growth in east Asia? World Bank Policy Research Working Paper No. 4597.

APPENDIX – A

TABLE I *UNIT ROOT TEST RESULTS*

ADF Test Statistic			**Philips-Perron Test Statistic**		
Variables Level		**1st Difference**	**level**	**1st Difference**	**Conclusion**
GDP	4.629	2.6253	1.599	-5.176	I(0)
ROT	2.775	1.9662	6.829	4.8642	I(0)
CUR	3.999	2.5641	11.158	1.3470	I(0)
EXCHR	6.787	5.0909	-1.198	-4.464	I(0)
GENOT	0.1266	-3.701	-1.510	-3.736	I(I)
EXTR	2.258	-4.559	-0.919	-6.385	I(0)
1% Critical	-3.6661	-3.649	-3.6661	-3.6752	
5% Critical	-2.9627	-2.953	-2.9627	-2.9665	
10% Critical	-2.6200	-2.616	2.6200	-2.6220	

**indicates significant at 1% or a rejection of the null hypothesis of no unit root at the 1% level*

TABLE II THE LONG RUN REGRESSION RESULTS

VARIABLES	**COFFICIENT**	**STANDARD ERROR**	**T-STATISTICAL**	**PROB.**
InC	4.7577	0.5763	8.2550	0.0000
InROT	0.2096	0.1252	1.6744	0.0060
InCUR	-0.0307	0.3470	-0.0886	0.9301
(D)InGENOT	0.1607	0.0613	2.6216	0.0144
(D)InEXCHR	0.0425	0.1237	0.3434	0.7340
(D)InEXTR	0.1447	0.0948	1.5259	0.0391
R-SQUARE	0.780			
ADJ R-SQUARE	0.737			
F-STATISTIC	18.45499			
D-W STATISTIC	1.9115			
PROB	0.00000000			

Source: *Author's Computation from E-views software 7.0*

REGULAR SCHOOL COMMUNITY ENGAGEMENT: PARADIGM FOR DEVELOPMENT OF TECHNICAL AND VOCATIONAL EDUCATION IN OGBA/EGBEMA/NDONI LOCAL GOVERNMENT AREA, RIVERS STATE

Ekeukwu Pureheart
Department of Vocational and Technology Education
Faculty of Education
Rivers State University, Port Harcourt
Email: pureheart.ekeukwu1@ust.edu.ng (+2348136109793)

Abstract
This study investigated regular school-community engagement as a paradigm for the development of Technical and Vocational Education in Ogba/Egbema/Ndoni Local Government Area, Rivers State. A descriptive survey design was adopted for the study, the population of the study comprised 1350 persons as community representatives and 500 persons as school representatives totalling 1,850 persons. The sample size was 555 made up of 405 respondents as community representation and 150 respondents as school representation. These were selected using simple random sampling technique. A 15-item, 5-point Likert scale structured questionnaire was used to collect data, and mean statistics was used to analyse data collected. The instrument was validated by experts in the Department of Vocational and Technology Education, Rivers State University. Findings reveal among others; that the community raises funds for the school through fund launching, levies and contributions etc. To meet some needs of the school, Public awareness programmes, and joint awards by the school and community will build a required level of awareness and reduce apathy for TVE. Community members form vigilante groups share intelligence with security agencies in the bid to provide and enhance adequate security for TVE development. Based on the findings of the study, it was recommended that efforts be made to encourage and strengthen community active interest in what goes on in the schools located in their vicinity and Greater collaboration between the school and her host community should be made in the bid to sharing intelligence and require supports to enhance a safer environment for the smooth sailing of TVE programmes.

Keywords: School, Community, Relationship, Development Technical, Vocational, Education, Training

Introduction
Every school is situated in a community, no single school exists on an island. Hence, the community makes the catchment area of the school. The community is a social system which has an unrestricted geographical area. Concerning the school, the community may be synonymous with neighbourhood. It may be a state, or local school district, or area served by an elementary or secondary school. Every school relies on its community entity for almost everything it requires such as teaching and non-teaching personnel, students, equipment, facilities funds and other resources. The school therefore cannot exist in isolation of the community. A symbiotic or mutual relationship needs to exist between the school and its community as neither can do without the other (Okorie, Emene & Egu, 2009).

According to Nnabuo and Emenalo (2012), the term Community school engagement is genuine cooperation in planning and working for the benefit of the school with the public giving as much as receiving ideas and resources. It involves a two-way process and flow of

ideas between the school and the community to ensure mutual cordial understanding and effective teamwork for the realization of Educational and Institutional goals of both the community and the school. It has been observed that the school depends on the community for most of its needs; water, land, skilled and unskilled labour, staff accommodation, sponsorship in times of financial need and for the continued existence of the school. School community engagement involves a series of activities and medium through which the school seeks to learn more (when necessary) about the purposes, programmes, problems and needs of society.

Most schools are built by the communities and handed over to the government. Inputs in the form of funds, personnel, ideas, societal norms, values and ethical beliefs are sent to the school by the community, they prescribe conditions for the control of the school activities and demands to know the happening in the school (Abraham, 2013). Additionally, these inputs are processed through teaching, assignment, exercise, researches, discussions, excursions, guidance, counseling and later sent back to the community as refined products made of disciplined, functional and employable individuals who are properly equipped to be useful to themselves, others and to serve the community in different capacities. In effect, both the school and community are social entities which are interdependent, interrelated and with a mutual relationship.

In most communities, demands are made from the public to the school to justify the resources given to them as to disabuse their minds from the fact that resources are misused, mismanaged and sometimes embezzled. Okorosaye and Orubite (2021), observed that school classrooms have doubled as classrooms for adult literacy activities, public health activities like immunization and public health enlightenment exercises and in emergency epidemic situations, school buildings are converted into makeshift hospitals and health centres. During electioneering school buildings have been used for registration of voters, political campaigns, voting proper and a lot of social engineering take place within the school premises and the community. According to Little (2011), there is the increasing recognition that partnership between the school and community are essential in efforts to expand when, where, how and what student learns especially as it concerns the training of persons with requisite skills to explore todays work place and in becoming a self-reliant person.

Technical and Vocational Education and Training (TVET) is that education meant for the training of persons to acquire requisite skills to explore today's work place and in becoming a self-reliant person. It is a comprehensive term referring to all forms and levels of the educational process involving in addition to general knowledge, the study of technologies and related sciences and the acquisition of practical skills, know-how, attitudes and understanding relating to occupations in the various sectors of economic and social life (UNESCO, 2011). This definition highlights the fact that TVET is designed to train skilled and entrepreneurial workforce that needs to create wealth that would help to reduce the menace of poverty and unemployment. From the highlights made from the definition of TVET above, it is obvious that the skilled and entrepreneurial workers to be trained by the school comes from a community and at the end of their training will return back to the community in other to create wealth that will help to reduce poverty and unemployment in that community. It was reiterated by Abraham (2013), that the school exists primarily for teaching and learning. There have been numerous complains on the poor state of technical and vocational education that is impeding its development. Studies by Eze (2013) and Okorosaye and Orubite, (2021) identified poor funding, apathy and insecurity as part of the problems facing technical and

vocational education. Meseasures in the past have been put by the government but yet no noticeable change witnessed, hence the need for a paradigm shift in approach towards resolving these problems.

Paradigm refers to a shift or new way or a model of doing something. The concept of paradigm represents a fundamental shift in how we perceive and interpret the world around us, in this regard we are dwelling on a shift in the way resolving technical and vocational education challenges have been handled so far. It encompasses not just individual meanings, but entire frameworks of understanding that shape our thoughts, actions, and interactions with others. paradigm serves as a lens through which we make sense of reality, guiding our beliefs, values, and priorities. It encompasses cultural norms, societal expectations, and personal experiences, all intertwined to form a cohesive worldview. Regular school community engagement can serve as a new model to resolving or fostering the development of technical and vocational education (Okorosaye and Orubite, 2021)

Idu (2013), posits that the extent of interaction between the school and the community depends largely on the administration of the school, the leadership style applied by the school management will to a great extent determine the nature and character of school-community engagement. According to Idu (2013), a crucial area of interaction between the school and the community is the training and development of the child. This is because the youths who attend the school are members of the community as well as members of the school which they attend. Therefore, the community and school collectively influence and shape the behaviour of the youth.

Idu (2013), further outlines seven areas of school-community interactions namely:
Economic Contributions: The school can provide expatriate services to community projects, the school also employs members of the community and purchase local products produced by the community. The community in turn provides funds for new school building, provision of materials and personnel for school project. In this way, an economic tie strengthens between the school and the community.

General Services: The school serves as a base for local groups like choir, scout, guides, concert and games. School also helps aged members of the community with health talks, the school could be used as postal address for the community. The equipment of the school could be used to clear the community playground and render necessary services to the community, while the community on the other hand provides security, through vigilante operation to ensure that the school infrastructures and equipment are safe. The community could also oblige the school critical community facilities as places of learning for the school etc.

Use of Physical Facilities: School classrooms, hall, teacher's quarters can be used by the community for meetings, ceremonies and seminars/workshops.

Research and Cultural Records: The community provides school with detail information on their culture and traditions. The community could also contribute artifacts to the school museum. The school on the other hand keeps records of local traditional events, the school further carries out research on local community history, songs etc.

Teaching: The community contribute local people as instructors to school especially in areas that requires traditional tutelage, while the school provide the community with Adult Literacy

for out of school youths, extra moral classes, seminars, workshops and professional correspondence courses.

Curriculum: The school supplies information and new ideas for use in the community and transmits the culture of the people. The use of and access to local facilities, general visit to areas of interest, provision of case studying materials etc., are community commitments in this regard.

Management: The school in many ways engages her staff and students in local community affairs. The school also involve students in community youth organization programs, trainings and management. Community participation in school management affairs comes by ways of integrating community members into school committees, community traditional institutions involving the school management in critical decision that will affect the future of the students.

Schools and communities working together towards a common goal can be beneficial. Communities can provide schools with a context and environment that can either complement and reinforce the values, culture and learning the schools provide for their student or negate everything the schools strive to accomplish (Ada, 1994). Communities also can furnish schools and the students in them with critical financial support system (Mattessich and Monsey, 1993). According to Tata (2014), the school as a social institution and agent of socialization needs to have a good relationship with the immediate and far communities. Symbolic relationship always exists between the school and the communities which leads to the success of the two. Cordial relationship between the school and community is a pre-requisite for achieving meaningful educational objectives in our community and nation at large (Gital, 2009). It is against this background that this research works advances findings on the roles of school-community relationship in the development of Technical and Vocational Education in Ogba/Egbema/Ndoni Local Government Area of Rivers State.

Statement of Problem

It is truism, that Technical and Vocational Education (TVE) is a great tool in wealth creation, since its focus and trainings are targeted at producing skilled, functional, economically viable, self-reliant and entrepreneurial members of a society. Unfortunately, this great tool for wealth creation (TVE) has not delivered effectively and bears little or unnoticeable presence in today's society due to great challenges it faces (Eze 2013). The brunt of this condition of TVET in the society is manifested in the high rate of unemployed able youths of the communities due to dearth of requisite skills and capabilities necessary for employment (Okorosaye and Orubite, 2021). Indeed, the repercussions of this ineffective state of TVE is suffered mainly by the community. Hence, the need for regular and cordial school-community engagement in dismantling the hurdles, including but not limited to poor funding, apathy for TVE and motivation, infrastructural deficiencies, insecurity amongst others.

Purpose of the Study

The main purpose of this study is to examine regular school community engagement as a paradigm for the development of Technical Vocational Education in Ogba/Egbama/Ndoni Local Government Area (ONELGA) of Rivers State. Specifically, the study sought to:

i) Find out how regular school community engagement enhances adequate funding of Technical and Vocational Education development in ONELGA.

ii) Examines how regular school community engagement reduces Apathy Technical and Vocational Education in ONELGA.
iii) Examines how regular school-community engagement enhances the provision of adequate security for Technical and Vocational Education development in ONELGA.

Research Questions

The following research questions guided the study:

i) How does regular school community engagement enhance adequate funding of Technical and Vocational Education development in ONELGA?
ii) How does regular school community engagement reduce Apathy for Technical and Vocational Education in ONELGA?
iii) How does regular school-community engagement enhance the provision of adequate security for Technical and Vocational Education development in ONELGA?

Hypotheses

The following hypotheses guided the study and was tested at 0.05 level of significance

i) There is no significant difference between the mean response of community representatives and school representatives on how regular school community engagement enhances adequate funding of Technical and Vocational Education development in ONELGA
ii) There is no significant difference in the mean response of community representatives and school representatives on how regular school community engagement reduces Apathy for Technical and Vocational Education in ONELGA
iii) There is no significant difference in the mean response of community representatives and school representatives on how regular school-community engagement enhances the provision of adequate security for Technical and Vocational Education development in ONELGA

Methodology

The study adopted the descriptive survey design to obtain information on regular school community engagement; paradigm for development of technical and vocational education in ogba/egbema/ndoni local government area, Rivers State. The study was carried out in Ogba/Egebma/Ndoni Local Government Area of Rivers State. The LGA has over 72 communities with one Federal College of Education (Technical) situated in Omoku. The population of the study comprised of 1,850 persons who are indigenes of Ogba/Egbema/Ndoni Local Government Area. This population (1850) comprises of 1350 persons as community representatives and 500 persons as school representatives. The sampling technique used in selecting the sample for this study was simple random sampling, A total of 555 respondents were selected. 405 respondents represented the community group and 150 respondents represented the school group, this sample size represent 30% of the total population of the study. The instrument used for this study was a Likert scale structured questionnaire titled ‘’Regular School-Community Engagement for TVE Development Questionnaire (RSCETVEDQ)’’ it comprises of fifteen (15) items based on the objectives of the study. The instrument was validated based on face and content value by two experts in the Department of Vocational and Technology Education, Faculty of Education, Rivers State University. The reliability of the instrument was established using Test-Retest method, Pearson Product Moment Correlation (PPMC) Coefficient was used for analysis. A reliability coefficient of 0.82 was established for the instrument. Data collected were analysed using two statistical tool, the mean and standard deviation. For a decision to be reached, the scaled

responses of respondents were computed. The results of the computations were used to calculate the grand mean (GM) of 3.00. thus, any item whose mean value does not reach up to 3.00 and above was not considered and accepted but rather rejected. The hypotheses were tested at 0.05 level of significance using Z-test.

Results and Discussion

Findings made by this study are presented and discussed as follows:

Research Question 1: How does regular school community engagement enhance adequate funding of Technical and Vocational Education development in ONELGA?

Table 1: Mean Responses on Funding for TVE Development in ONELGA

S/N	QUESTIONNAIRE ITEMS	Community Representatives			School Representatives		
		$\bar{X}_1$	SD1	DECISION	$\bar{X}_2$	SD2	DECISION
1.	Community members launch funds to address specific need of school in their community	4.27	0.50	Agree	4.20	0.52	Agree
2.	Wealthy community members sponsor competitions, projects and programmes in schools	4.47	0.23	Agree	4.45	0.26	Agree
3.	Members of community are most times compelled to pay some levies and dues in order to raise money to address a pressing need of school	4.07	0.50	Agree	4.00	0.47	Agree
4.	Community sometimes engages the expatriate service of school in projects in the community in order to enable the school raise fund	4.18	0.44	Agree	4.27	0.42	Agree
5.	The community can compel the oil companies operating in their area to provide termly some financial support to their schools as part of their cooperate social responsibility to the community?	4.20	0.50	Agree	4.18	0.48	Agree
	Grand Mean	**4.24**	**0.43**	**Agree**	**4.22**	**0.48**	**Agree**

Source: Researchers Field Result; 2024

The result from Table 1 above shows that the mean responses from each item from 1-5 is more than 3.0 and at such is accepted. This shows that through fund launchings, financial assistance from wealthy members of community, community levies, engagement of expatriate services of school, and fund supports from multi-national company operating in the community are ways the community enhances adequate funding for the school.

Research Question 2: How does regular school community engagement reduce Apathy for Technical and Vocational Education in ONELGA?

Table 2: Mean Responses on Reduction of TVE Apathy in ONELGA

S/N	ITEM	Community Representatives			School Representatives		
		$\bar{X}_1$	SD1	DECISION	$\bar{X}_2$	SD2	DECISION
6.	Public enlightenment program from the school on the importance of TVE will help community members realize that TVE is the major gateway out of the high rate of unemployment of community youths?	3.86	0.50	Agree	3.83	0.52	Agree
7.	Joints prizes and award by the school and community on best performing TVE student will help motivate and enable others to enroll for TVE?	4.16	0.26	Agree	4.05	0.23	Agree
8.	Politician from communities may push for the equality of technical degree and other academic degrees in the bid to eradicate apathy for TVE?	4.07	0.48	Agree	4.09	0.49	Agree
9.	The realization that TVE will enable a person acquires skills and capabilities that will enable him become self-reliant and economically prosperous will turn the spate of dislike for TVE?	4.46	0.40	Agree	4.52	0.45	Agree
10.	The public awareness that today's work place do not merely emphasis academic paper and qualification but technical skills and capabilities with which one will deliver on a particular task or job role will eradicate Apathy for TVE and build positive image and likeness for TVE?	4.34	0.48	Agree	4.30	0.50	Agree
	Grand mean	**4.18**	**0.42**	**Agree**	**4.16**	**0.44**	**Agree**

Source: Researchers Field Result; 2024

Above results from table 2 shows that the mean for items from 6-10 is more than 3.0 and at such is accepted. This shows that public enlightenment programs, joint prize awards by the school and community, equalization of technical degrees and other academic degrees, and public awareness on the skills requirement of today's work place enhances the reduction of apathy for TVE in ONELGA.

Research Question 3: How does regular school-community engagement enhance the provision of adequate security for Technical and Vocational Education development in ONELGA?

Table 4.3: Mean Responses on Provision of Adequate Security for TVE Development in ONELGA

S/N	ITEM	Community Representatives			School Representatives		
		$\bar{X}_1$	SD_1	DECISION	$\bar{X}_2$	SD_2	DECISION
11.	Community vigilante group aids in securing school buildings and faculties	4.27	0.52	Agree	4.31	0.49	Agree
12.	Community members provide intelligence to school authorities on suspected security threats to school environment	4.47	0.23	Agree	4.50	0.24	Agree
13.	Community leaders draws the attention of security agencies and aids in supporting securing operatives in their operations in a case of attack on the school	4.07	0.49	Agree	4.06	0.48	Agree
14.	Community members depose information that leads to arrest of school vandals and possible recovery of stolen items from the school premises	4.18	0.45	Agree	4.13	0.43	Agree
15.	Community members mobilize to catch and handover to security agencies hoodlum in their community who has been indicted of participating in the vandalization of school facilities	4.20	0.50	Agree	4.23	0.48	Agree
	Grand Mean	**4.24**	**0.44**	**Agree**	**4.25**	**0.42**	**Agree**

Source: Researchers Field Result; 2024

Considering table 3 above, Responses shows that mean for each item from 11-15 is more than 3.0 and at such is accepted. This shows that community vigilante groups, provision of intelligence by community members, mobilization of community members to go after suspicious members who are believe to be vandals of school properties enhances adequate security provision for TVE development in ONELGA.

Hypotheses

HO₁: There is no significant difference between the mean response of community representatives and school representatives on how regular school community engagement enhances adequate funding of Technical and Vocational Education development in ONELGA

Table 4: Z-test analysis on regular school community engagement enhances adequate funding of Technical and Vocational Education development in ONELGA

Respondents group	Mean	SD	N	Df	Z-Cal	Z-Crit	Decision
Community Representatives	4.24	0.43	405	553	0.40	1.96	Accepted
School Representatives	4.22	0.48	150				

Source: Researchers Field Result; 2024

Table 4 revealed that Z-Cal (0.40) is less than Z-Crit (1.96). This indicates that the null hypothesis is accepted. Therefore, there is no significant difference between the mean responses of community representatives and school representatives on how regular school community engagement enhances adequate funding of Technical and Vocational Education development in ONELGA

HO₂: There is no significant difference in the mean response of community representatives and school representatives on how regular school community engagement reduces Apathy for Technical and Vocational Education in ONELGA

Table 5: Z-test analysis on school-community relationship reduction of apathy for Technical Vocational Education and Training development in ONELGA

Respondents group	Mean	SD	N	Df	Z-Cal	Z-Crit	Decision
Community Representatives	4.18	0.42	405	553	0.50	1.96	Accepted
School Representatives	4.16	0.44	150				

Source: Researchers Field Result; 2024

Table 5 revealed that Z-Cal (0.50) is less than Z-Crit (1.96). This indicates that the null hypothesis is accepted. Therefore, there is no significant difference in the mean responses of community representatives and school representatives on how regular school community engagement reduces Apathy for Technical and Vocational Education in ONELGA.

HO₃: There is no significant difference in the mean response of community representatives and school representatives on how regular school-community engagement enhances the provision of adequate security for Technical and Vocational Education development in ONELGA

Table 6: Z-test analysis on school-community relationship enhancement of adequate security for Technical Vocational Education and Training development in ONELGA

Respondents group	Mean	SD	N	Df	Z-Cal	Z-Crit	Decision
Community Representatives	4.24	0.44	405	553	0.24	1.96	Accepted

School Representatives	4.25	0.42	150

Source: Researchers Field Result; 2024

Table 6 revealed that Z-Cal (0.24) is less than Z-Crit (1.96). This indicates that the null hypothesis is accepted. Therefore, there is no significant difference in the mean responses of community representatives and school representatives on how regular school-community engagement enhances the provision of adequate security for Technical and Vocational Education development in ONELGA

Discussion of Findings

The findings in research question one reveals that through fund launching, financial assistance from wealthy members of community, community levies, engagement of expatriate services of school and fund support from multi-national operating in the community are ways the community could enhances adequate funding for TVE in ONELGA. Funding is a critical requirement for an effective and efficient TVE programe. This finding falls in tandem with views of Mattessich and Monsey (2013) who posited that communities can furnish schools and the students in them with critical financial support system. In same vein, Nasiru (2018) and Gital (2019) were of the view that the community provides schools with lands to be established, funds as well as provides pupils with educational materials for the overall and general development of Education.

From the findings in research question two, it is revealed that public enlightenment programs, joint prize award by the school and community, equalization of technical degrees and other academic degrees, and public awareness on the skill requirement of today's work place reduces Apathy for TVE. This was the position of Nworlu and Elechi (2013) who held that the disparity between technical degrees and other academic degrees in Nigeria has led to apathy, unlike other countries where technical degrees are accorded a very high place for employment. Also, in support of the above, Kehinde and Adewuyi (2015) opined that government should encourage interested persons by giving of scholarship to students and technical teachers for further studies in vocational and technical courses, they added that seminar and workshops should be organized to enlighten the public about the importance of vocational and technical education.

Also, findings in research question three reveals that Community vigilante groups, provision of intelligence by community members and mobilization of community members to go after suspicious members who are believed to be vandals of school properties enhances adequate security provision for TVET programs in ONELGA. In support of the above, Okorie, Ememe and Egu (2019) found that communities have been known to organize local vigilante groups to protect school property. In same vein Emenalo (2010) posit that community provides information to security agencies on possible or identified threats to school property. He added that community members form vigilante groups to watch over school properties.

Conclusion

Communities play active roles in the development of the school in their locality, therefore, robust and regular school-community engagement is very important in the development of Technical and Vocational Education in Ogba/ Egbema/Ndoni Local Government Area of Rivers State. This fact is evident in the community's effort in fund launching, levies and engagement of expatriate services of school in the bid to enhance adequate funding of schools and TVE programs. Also school community efforts in public awareness programs, formation

of vigilante group and provisions of intelligence helps in no little measure in reducing apathy for TVE and guarantee adequate security for TVE development. It is hoped that continuous active collaboration between the school and community will in no little way earn TVE the desired envious status in no distant time.

Recommendations

Based on the findings of this study, the following recommendations are made:

1) Communities should be made more active in every aspect of school activity, as she is a sure and reliable entity in reaching to TVE needs especially as it concerns funds.
2) TVE institutions should amplify the campaign against apathy for TVE, working with community based non-government organizations in driving a vigorous campaign emphasizing TVE as the sure tool in surviving the skill requirements of today's work place.
3) Greater collaboration between the school and her host community should be made in the bid to sharing intelligence and require supports to enhance a safer environment for the smooth sailing of TVE programs.

REFERENCES

Abraham N. & Ememe, O. (2012). "Effective School-community Relation as a key performance indication for the secondary school administration in Aba South District, Nigeria. *Journal of Curriculum and Teaching*, vol. no. Sciedu Press.

Abraham, N.M. (2013). Educational Administration in Nigeria, Port Harcourt: Apm Unique publisher.

Abraham N.M. & Leigha, M.B. (2007). Developing and sustaining student's interest in the classroom. *Journal of Technical and Science Education,* 16(1 &2):138-144.

Akaniwor, G. (2007). Self-method as applied to the training of vocational and technical trainers. Special method of technology instructions, Port Harcourt, Wilson publishing company.

Aminu, J. (2006). Quantity and Stress in Nigeria Education. Zaria University Press.

Emenalo, F.C. (2010). The School and Community in Anukam I.L. Okunanuri. I.O. & Ogbonna, R.N.O. Basic Text I Education Management Owerri. Eeheeh versatile.

Federal Republic of Nigeria (2013). National Policy on Education ,6th edition. NERDC Press, Lagos.

Gital, M.A. (2009). "The impact of school-community relationship on primary education A case study of so me selected communities of Tafara Belewa Loca Government Area in Bauchi State. Unpublished Ph.DE project. *College of Education, Azare, Affiliated to the University of Maidaguri, Nigeria.*

Kehinde, T.M. and Adewuji, L.A. (2015). Vocational and Technical Education: A viable tool for Transformation of the Nigerian Economy: *International Journal of Vocational and Technical Education Research,* vol. 1 no.2. European centre for research training and development UK.

Little G.J. (2011). Sustainable school public relations activities – An imperative for improving enrolment into technical colleges in Nigeria. *Trends in Education Studies*. 1 (3), 67 – 75.

Maluta, M.G. (2007). An introduction to sociological foundation of Education. Calabar: But-Bass Educational Books (BEB).

Mitrofanova, Y. (2011). Building Community School Relations. http://cancaster. uni.edu/community/articles/communityschools.html.

Nasiru and Gital (2019). Strategies for improving quality technical vocational education through industry – school relations. African Journal of Historical Science in Education. 15 (1), 100 – 115.

Nnabuo G.A and Emenalo E (2012). vocational skill development programmes in North – East States of Nigeria. *Journal ofEducation in Developing Areas*. 18(1), 15 –35.

Ogundele, M.O., Oparinde, F.O. & Oyewale, M.K. (2012). Community-school relations and principals administrative effectiveness of secondary schools in Kwara State. http://www.mcser.org/images/studies/JESRJOURNAL/jesrseptember2012.

Okeke, B.S. (1997). The School and the Community in B.S. Okekeand C.N. Uwazuruike (Eds). *Introduction to Education Administration Owerri.* Klet-ken publishers.

Okeke, N.C. Ememe, Ememe, O.N. & Egu, R.H.N. (2009). School Community Relations in the development of secondary schools: A focus on Aba Education Zone. *African Journal of Education and Development Studies*, 6(1).

Okorie F., Emene A.E & Egu C.J (2019). Sustaining School-Community engagement for educational development classroom. *Journal of Technical and Science Education,* 16(1 &2):138-144

Okorosaye F.O, and Orubite A. (2021). Vocational and technical education in Nigeria: Issues and challenges. *Journal of Technical Education.* 6(1), 100 – 115.

Oranu, R.N. (1992). Vocational Education and Manpower Development, Vocational/Technical Education, Manpower Development NVA.

Sa'ad, T.U. (2007). The impact of Domestic Responsibilities on the Academic Achievement of married women in Tertiary Institutions of Bauchi State. Unpublished M.Ed thesis Bayero University, Kano.

Sa'ad, T.U. and Nasiru, A.m (2010). "The significance of school-community relationship on education". *Azare Journal of Education*, 8(1).

Tata Umar Sa'ad & Abdulahi, M. Sadiq (2014). "The Relevance of School-community Relationship on the Development of primary Educationin Azare Metropolis of Bauchi State, Nigeria. *Journal of Research and methods in Education.* Vol.4(6).

Uzougwu, N.E. (2017). Technical vocational education and training (TVET) in Nigeria: The way forward. Journal of Academic Excellence. 15(1). 41 – 59

UNESCO (2011). Revised recommendation concerning technical and vocational education in normative instrument concerning technical and vocational education.

UNESCO (2012). Third International congress in TVET. http// www. Unesco.edu.org

SUB-THEME 13
INSTRUCTIONAL DELIVERY TECHNOLOGIES

GAMIFICATION IN EDUCATION: A SYSTEMATIC REVIEW OF LITERATURE ON KAHOOT, QUIZIZZ AND QUIZLET AND IMPLEMENTATION IN NIGERIA

OLADOSU, Kamaldeen Korede, **GAMBARI**, Amosa Isiaka, **KUTA**, Ibrahim Ismaila, **OJENIYI**, Joseph Adebayo
[1]Department of Educational Technology
Federal University of Technology, Minna, Nigeria.
[2]Department of Cyber Security Science
Federal University of Technology, Minna, Nigeria.
Corresponding author:
Email: kamaloladosu@gmail.com
Tel: +2347064834697

Abstract

This systematic review explores the impact and implementation of gamified learning tools Kahoot, Quizizz, and Quizlet within educational settings, with a focus on their potential adoption in Nigeria. The review synthesizes global studies highlighting how these platforms enhance academic performance, student engagement, and motivation. Kahoot fosters interactive learning through real-time quizzes; Quizizz offers personalized assessments enriched with game elements, while Quizlet supports vocabulary retention via flashcards and spaced repetition. Results indicate widespread effectiveness, especially in language learning and reading comprehension. Though predominantly studied outside Nigeria, the findings suggest strong potential for application in Nigerian classrooms, where challenges such as low motivation and large class sizes persist. The study recommends integrating these tools into pedagogy, supported by infrastructural investment and teacher training, to improve learning outcomes and engagement in Nigeria's resource-constrained education sector.
Keywords: Gamification, Kahoot, Quizizz, Quizlet, TVET, Nigeria, Digital Education, Interactive Learning, EdTech, 21st Century Skills, Technology Integration.

1.0 Introduction

The technological revolution of the 21st century has significantly transformed classroom dynamics, raising concerns about the continued effectiveness of traditional pedagogical methods. Contemporary students, often immersed in digital environments, are increasingly disengaged from conventional instructional delivery. Ofosu-Ampong (2020) argued that the misalignment between traditional teaching approaches and modern learners has led to low motivation, reduced academic achievement, and limited engagement. In response to these challenges, gamification has emerged as a promising pedagogical strategy.

Several gamified tools such as Kahoot! Quizizz, and Quizlet have become increasingly popular in educational settings. These platforms use quizzes, flashcards, and interactive challenges to make lessons more dynamic and enjoyable. Kahoot! for example, enables educators to create competitive quizzes answered in real-time, fostering classroom engagement (Wang & Tahir, 2020; Maraza-Quispe, 2024). Quizizz enhances the learning experience by incorporating avatars, memes, and music, supporting both group and individual assessments (Callista Anak Yunus & Kim Hua, 2021). Quizlet, on the other hand, offers multiple study modes such as flashcards and matching games to improve vocabulary retention and accommodate diverse learning styles (Sippel, 2022; Platzer, 2020).

Study Objectives

i. To evaluate the impact of Kahoot, Quizizz, and Quizlet on learning

ii. To examine the implementation of these tools in Nigeria's educational Settings

2.0 Methodology

This systematic review was designed to analyse the existing literature on the usage of gamification tools, specifically Kahoot, Quizizz, and Quizlet in the educational sector in Nigeria. The review followed a planned and scientific methodology to find, analyse and summarise relevant studies. The process includes search strategy formulation, application of inclusion and exclusion criteria, and data extraction and analysis.

2.1 Search Strategy

Creating a thorough search plan to find pertinent research was the first stage in the evaluation process. Google Scholar with an emphasis on education were among the many resources explored to find studies. Carefully selected keywords and search criteria allowed us to include a broad range of works about gamification in Nigerian education.

The primary search terms used were:

- "Kahoot in Nigeria"
- "Quizizz in Nigerian education"
- "Quizlet in Nigerian classrooms"
- "Gamification in Nigerian schools"
- "Educational technology in Nigeria"

2.2. Inclusion and Exclusion Criteria

The following inclusion and exclusion criteria were utilised in selecting the studies used in this study.

Inclusion Criteria

i. Studies related to the application of Kahoot, Quizizz, or Quizlet.
ii. Peer-reviewed articles.
iii. Studies related to the examination of the impact of these tools on the educational sector.
iv. Articles published in the last 10 years to capture recent trends and findings in the field.
v. Studies published in the English language.

Exclusion Criteria

i. Articles not related to the application of Kahoot, Quizizz, or Quizlet
ii. Articles that were published before 2010
iii. Studies that focus on gamification in non-academic contexts
iv. Studies not related to the examination of the impact of these tools on the educational sector.
v. Studies in other languages.

2.3 Data Extraction and Analysis

Following the first search, the papers that were found were filtered according to their titles and abstracts to evaluate their suitability for the review. The pertinent paper was selected based on the exclusion and inclusion criteria.

Data extraction involved collecting key information from each study, including:

- Authors
- Year of publication
- Research methodology (e.g., experimental, quasi-experimental, case study)
- Variables studied (e.g., academic performance, motivation, engagement)
- The locale of the study within Nigeria
- Main findings or outcomes of the study

A thematic analysis of the study data revealed consistent themes regarding the usefulness and influence of Quizizz, Kahoot, and Quizlet in Nigerian classrooms. The findings section

presents a summary and analysis of the analysis, providing information on how various gamification tools are impacting education in Nigeria.

3. Results

The section covers the results of the findings from the articles as it relates to the use the tools in the academic sector as presented in Table 1, 2 and 3.

Kahoot

Table 2: The Use of Kahoot in the academic sector

SN	Authors	Methodology	Variables of the study	Locale of the study	Study Outcome
1.	Ismail and Mohammad (2017)	Cross-sectional survey	Formative assessment	Malaysia	Kahoot is a potential formative assessment tool that is practicable and practical, making learning entertaining. It can be used to drive students to study. However, as medical students perceived, Kahoot was not the strongest tool for simplifying complex subjects.
2.	Hou (2018)	Quasi-experimental design	Attitude and satisfaction	Taiwan	The results showed that students were generally satisfied with Kahoot and that their gender and level of English ability were related to their learning motivation in the end. Students also showed a good attitude towards using the IRS.
3.	Claudio et al. (2020)	Quasi-experimental design	Academic performance, perception and attitude	Chile	According to the quasi-experiment findings, there was a statistically significant difference between the low-stakes test scores of students who utilised Kahoot and those who did not. Furthermore, the survey's findings showed that students had very favourable attitudes and impressions about using Kahoot, which improved the learning environment in the classroom and encouraged better academic performance.
4.	Wahyumunika et al. (2021)	Experimental design, post-test only control group	Performance	Indonesia	It suggested acceptance of the null hypothesis. It was determined that the TPS strategy's application in conjunction with Kahoot! had no discernible impact on students' reading comprehension. The TPS approach applies to various skill sets.
5.	Quiroz et al. (2021)	Quasi-experiment, pre-test-post-test	Academic performance	Chile	Utilising the Kahoot! app, the experimental treatment's results showed an improvement in vocabulary understanding of English words with a substantial variation and a medium effect size. This generally indicates that to improve English learning in Chilean classrooms, new tactics must be implemented using the ICTs that are now accessible.
6.	Marsa et al. (2021)	Mixed-method approach, qualitative and quantitative	Academic achievement, motivation, perception and attitude	Indonesia	The results pertained to the impact of Kahoot! The use of games in teaching reading comprehension significantly enhances engagement, perception, and motivation, and fosters a positive attitude. It impacted kids' reading comprehension performance. Consequently, it may be inferred that employing Kahoot! Game with elevated engagement enhances students' perspective, motivation, and positive attitude, so influencing their reading comprehension performance.
7.	Ayoup (2021)	Pre-experimental case study	Academic achievement and engagement	Malaysia	The t-test result indicates that the students' pre- and post-test accounting subject achievement scores differ significantly. Interviews reveal how much students enjoyed using Kahoot for learning! and it motivates them to learn more about the topic.
8.	Korkmaz and Öz (2021)	Quasi-experimental	Academic performance and attitude	Turkey	The results of the research showed that after a seven-week intervention that included reading questions, learners' reading scores significantly improved. In addition, the survey respondents' responses to the open-ended questions showed that they not only held favourable sentiments towards the use of Kahoot

Quizizz

Table 3: The Use of Quizizz in the academic sector

SN	Authors	Methodology	Variables of the study	Locale of the study	Outcome
1.	Zhao (2019)	Case study	Satisfaction	Indonesia	Students report that Quizizz had a favourable impact on their learning experiences after utilising it for in-class tasks. Higher ratings on the instructor's teaching evaluation and higher ratings on user satisfaction with Quizizz are reported for class sections where the app is used more frequently.
2.	Priyanti et al. (2019)	The quasi-experimental, post-test-only control group	Performance	Indonesia	The results of the reading comprehension text, which were primarily literal recognition characteristics, supported the small effect. To sum up, Quizizz had an impact on students' reading comprehension.
3.	Pitoyo et al. (2020)	Descriptive research design and interview protocol	Perception and opinion	Indonesia	The study's findings demonstrate that after taking multiple gamified Quizizz tests, students were driven and desired to learn more in-depth information. Test reports, Time limit, Leaderboard, and Memes were among the game features that piqued their curiosity.
4.	Permana and Permatawati (2020)	Descriptive survey and quasi-experimental	Performance and interest	Germany	The outcomes demonstrated how useful Quizizz was as a formative assessment tool for learning German. The use of Quizizz in the classroom was also well-received by students. Therefore, to encourage greater student engagement with the learning process, teachers should think about implementing creative and enjoyable assessment systems in the future.
5.	Zuhara et al. (2020)	Quasi-Experimental, pretest-post-test	Academic performance	Indonesia	According to the findings, there are variations in students' cognitive learning outcomes between the experimental class and the control class, and the Problem-Based Learning model employing Quizizz evaluation influences students' cognitive learning outcomes. In summary, the Quizizz assessment model of Problem-Based Learning has a favourable effect on the cognitive learning outcomes of SDIT Al-Madina fifth-grade students.
6.	Yulianto (2020)	Pretest-post-test control group design	Learning outcome and motivation	Indonesia	With the help of Quizizz media, the STAD learning paradigm greatly influences students' motivation to learn, fostering a supportive learning environment. This methodology, which incorporates group prizes and quizzes, boosts student interest in learning and produces better learning results in the Indonesian history course.
7.	Callista Anak Yunus and Kim Hua (2021)	Quasi-experimental, pretest-post-test approach	Performance and gender	Malaysia	The findings are examined in terms of the overall performance of the students using Quizizz as well as a gender comparison to look for any appreciable differences in performance between male and female users.
8.	Munuyandi et al. (2021)	Descriptive approach	formative assessment tool	Malaysia	The study emphasises the usefulness of Quizizz as a formative assessment tool for teaching Tamil students' Malay grammar, emphasising the students' enthusiastic responses.

9.	Ramadani et al. (2021)	Mixed method approach	Academic performance, motivation	Jakarta	The primary conclusions drawn from this research are as follows: (1) Quizizz has a positive impact on student's academic achievement in grammar and reading as well as their motivation to learn; (2) students have positive opinions about Quizizz's challenging features and interesting appearance; and (3) students enjoy using Quizizz as a distance learning tool.
10.	Khasanah and Lestari (2021)	Quantitative research design	Academic performance	Indonesia	According to the study, when compared to worksheet media, Quizizz media considerably enhanced the mathematics learning results of students in class XI. Students in the eleventh grade who demonstrated a high level of learning independence had a very clear link between learning media and autonomous learning, which may have consequences for media choice and learning media interactions.

Quizlet

Table 4: The Use of Quizlet in the academic sector

SN	Authors	Methodology	Variables of the study	Locale of the study	Outcome
1.	Fatih and Kağan (2019)	Mixed-method approach	Academic achievement and perception	Turkey	The findings demonstrated that there was a substantial difference between the two groups when using Quizlet to learn vocabulary. Research has shown that Quizlet improves students' vocabulary development, especially in the area of word recognition. According to the surveys, students thought Quizlet was a useful tool for learning vocabulary.
2.	Maulida et al. (2024)	Pretest-post-test experimental design	Academic achievement and interest		These findings demonstrate the rejection of the null hypothesis (H0) and acceptance of the alternative hypothesis (Ha). Thus, the use of the Quizlet application has a considerable impact on vocabulary mastery according to this research.
3.	Chaikovska and Zbaravska (2020)	Pretest-post-test experimental design	Academic achievement	Ukraine	The experiment's outcomes validated the theory. The results demonstrated that the experimental group's vocabulary learners had increased at the post-test after utilising Quizlet and the spaced repetition technique to prepare undergraduates for the state English exam.
4.	Bueno-Alastuey and Nemeth (2020)	Pretest-post-test experimental design	Academic achievement and perception		The study's findings indicated that while there was no statistically significant distinction between the two approaches in terms of receptive or productive vocabulary acquisition, and both strategies assisted students in learning new words, participants seemed to favour the Quizlet methodology more.
5.	Sailin et al. (2019)	Mixed-method approach	Academic achievement and perception	Malaysia	The outcome demonstrated that utilising Quizlet significantly improves students' performance in the Science course. According to the poll results, students had a positive view of using Quizlet.
6.	Okkan and Aydin (2020)	Analytic-deductive design	Learning motivation	Turkey	The findings showed that while using Quizlet raises students' expectations for a quick reward from the teacher, it has little effect on their internal motivation to acquire language. Researchers also discovered that EFL students are highly motivated to pick up new terminology.

7.	Yüksel et al. (2020)	Quasi-experiment	Academic achievement, perception of use and perception of usefulness	Turkey	The findings showed that: (1) the students gained more technical vocabulary knowledge through DFs; (2) they thought that DFs were a good way to study technical vocabulary; (3) they thought that the Quizlet app was helpful and that this helped them succeed in the DF condition; and (4) using digital apps to practise positively predicted using the Quizlet application.
8.	Shyr et al. (2021)	Mixed-method, qualitative and quantitative approach	Learning performance, learning interests	Taiwan	The findings showed that learners in the Kahoot-based IRS reported greater learning interests, choice, and group self-efficacy in addition to doing noticeably better in mathematics learning performance. Comparatively speaking to the control group, students in the Quizlet-based IRS remedial classroom expressed greater satisfaction with learning interest, value, effort, and choice.

3.1 Discussion of Results

Impact of Gamification such as Kahoot, Quizizz, and Quizlet on learning

The findings from the articles indicate that Kahoot, Quizizz, and Quizlet have positive impacts on academic performance, student engagement and motivation across different educational settings globally.

Kahoot has been widely reported to improve academic performance, and student engagement and motivate students. For instance, Claudio *et al.* (2020) found that students had very favourable attitudes and impressions about using Kahoot compared to students who did not, which improved the learning environment in the classroom and encouraged better academic performance. Similarly, Marsa *et al.* (2021) confirms that the use of Kahoot games in teaching reading comprehension significantly enhances engagement, perception, and motivation, and fosters a positive attitude. It impacted students' reading comprehension performance. However, some studies, such as Wahyumunika *et al.* (2021) indicated that there is limited impact in some contexts, such as Kahoot being used along with the TPS strategy for reading comprehension. Overall, Kahoot was found effective in enhancing learning.

The results also indicated that Quizizz consistently demonstrated effectiveness in enhancing learning through motivation and academic performance. Studies such as Priyanti *et al.* (2019) indicated that Quizizz had an impact on students' reading comprehension. Yulianto (2020) highlighted that Quizizz greatly influences students' motivation to learn, fostering a supportive learning environment which improves comprehension, specifically, in subjects like history and language. Pitoyo *et al*. (2020) emphasised that after taking multiple gamified Quizizz tests, students were driven and desired to learn more in-depth information. Test reports, Time limit, Leaderboard, and Memes were among the game features that piqued their curiosity.

Quizlet has been shown to significantly enhance academic achievement and vocabulary acquisition. Studies such as Fatih and Kagan (2019) indicated that Quizlet improves students' vocabulary development, especially in the area of word recognition. Additionally, Chaikovska and Zbaravska (2020) demonstrated that the experimental group's vocabulary learners had increased at the post-test after utilising Quizlet which significantly boosted learning of vocabulary and exam preparation. However, Okkan and Aydin (2020) noted that Quizlet raises students' expectations for a quick reward from the teacher, it has limited influence on their intrinsic motivation to acquire language. Hence, gamification has a positive impact on learning outcomes, motivation, and engagement. The application aids in carrying out formative assessments and specific tasks like vocabulary learning or reading comprehension.

Implementation of these tools in Nigeria's educational settings

The positive outcome observed across diverse global settings indicates that the implementation of gamification such as Kahoot, Quizizz, and Quizlet could be significantly effective if imbibed in Nigeria’s education sector. Nigeria face challenges in its academic sector such as low student engagement, limited resources, and large class sizes. Ofosu-Ampong (2020) argued that the disengagement between traditional teaching methods and the learners led to classroom challenges such as low motivation, low learning satisfaction, lack of engagement and low academic achievement (Niyi Jacob *et al.,* 2024). Tools like Kahoot, Quizizz, and Quizlet foster interactive learning and motivate students which could significantly improve the learning process and methods of teaching in Nigerian classrooms (Ismail & Mohammad, 2017). Also, the gamified nature of these tools will enable learning to be accessible and fun for students who find traditional learning methods less engaging (Díaz-Ramírez, 2020). Quizlet is equally useful in teaching vocabulary in Nigeria where students are taught in a second language (Quiroz *et al.,* 2021). Furthermore, such forms of tools are cheaper, readily available, and can be implemented across different courses, ideal for

Nigeria's resource-constrained educational environment. Nigeria also faces challenges such as inadequate internet connectivity and technical training, these tools have the potential to drastically shift learning in Nigerian schools for the better.

4.0 Conclusion and Recommendations

This review highlights the importance of the concept of gamification in learning, particularly through tools like Kahoot, Quizizz, and Quizlet. These tools have been found to enhance student's awareness, interest, and achievement in learning in varied settings. Through the use of games in learning like the leaderboard, rewards, and the interactivity of the quizzes in the learning process it is easier for learners to engage themselves better and even understand the various aspects of the learning topic.

The main findings of the reviewed literature reveal that all three tools significantly enhance learning outcomes. Kahoot leads to active participation and a positive learning attitude, on the other hand, Quizizz is more effective as for formative assessment tool that enhances motivation as well as understanding. Quizlet is most useful in vocabulary since the Quizlet utilizes functions such as spaced repetition to improve the chances of the content being retained. In Malaysia, Indonesia, Chile, Turkey and other countries, the studies unveil the effects of the used tools on performance in general but especially in language and reading comprehension.

Based on the positive results obtained, the following recommendations are made for educators, policymakers and researchers in Nigeria:

1. Educators should incorporate these gamified tools into teaching practices to help students better understand and retain knowledge. They can be employed to support the conventional form of training, and where the learners' motivation or activity level is wanting.
2. The government should encourage the adoption of these tools by facilitating the infrastructure to run these applications; schools should guarantee networks and teachers should be trained on how to apply the platforms correctly.
3. Future research should focus on the local use of these tools in Nigeria through studies in an educational context. examining their specific impacts on learning outcomes, particularly in underserved communities.

References

Ayoup, H. Et. al. (2021). Interactive Kahoot! - An application to Enhance the Learning of Accounting Subject in School. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, *12*(3), 2305–2312.

Bueno-Alastuey, M. C., & Nemeth, K. (2020). Quizlet and podcasts: effects on vocabulary acquisition. *Computer Assisted Language Learning*, *35*(7), 1–30. https://doi.org/10.1080/09588221.2020.1802601

Callista Anak Yunus, C., & Kim Hua, T. (2021). Exploring a gamified learning tool in the ESL classroom: The case of Quizizz. *Journal of Education and E-Learning Research*, *8*(1), 103–108.

Chaikovska, O., & Zbaravska, L. (2020). The efficiency of Quizlet-Based EFL vocabulary learning in preparing undergraduates for State English exam. *Advanced Education*, *7*(14), 84–90.

Claudio , C.-M., Véliz, L., & Véliz-Campos, M. (2020). Game-based student response systems: The impact of Kahoot in a Chilean Vocational Higher Education EFL classroom. *CALL-EJ, 21(1), 64-78.*

Díaz-Ramírez, J. (2020). Gamification in engineering education – An empirical assessment on learning and game performance. *Heliyon*, *6*(9), e04972. https://doi.org/10.1016/j.heliyon.2020.e04972

Fatih, T., & Kagan, B. (2019). The effects of quizlet on foreign language learners' vocabulary learning success and perceptions. *I-Manager's Journal of Educational Technology*, *16*(3), 44.

Franco, D. C. (2022). Gamification as an engagement, learning and interaction strategy for distance education in Mozambique. *Elsevier EBooks*, 71–81. https://doi.org/10.1016/b978-0-323-91185-6.00010-0

Guerrero, M., Espina-Romero, L. C., & Ángel Alberto Nava-Chirinos. (2022). Gamification in the University Context: Bibliometric Review in Scopus (2012-2022). *International Journal of Learning, Teaching and Educational Research*, *21*(5), 309–325. https://doi.org/10.26803/ijlter.21.5.16

Hou, Y. (2018). Integration of Kahoot into EFL Classroom. *HCI International 2018 – Posters' Extended Abstracts*, 31–37. https://doi.org/10.1007/978-3-319-92285-0_5

Ismail, M. A.-A., & Mohammad, J. A.-M. (2017). Kahoot: A Promising Tool for Formative Assessment in Medical Education. *Education in Medicine Journal*, *9*(2), 19–26. https://doi.org/10.21315/eimj2017.9.2.2

Khasanah, K., & Lestari, A. (2021). The Effect of Quizizz and Learning Independence on Mathematics Learning Outcomes. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, *6*(1), 63–74. https://doi.org/10.24042/tadris.v6i1.7288

Korkmaz, S., & Öz, H. (2021). Using Kahoot to Improve Reading Comprehension of English as a Foreign Language Learners. *International Online Journal of Education and Teaching*, *8*(2), 1138–1150. https://eric.ed.gov/?id=EJ1294319

Maraza-Quispe, B. (2024). Impact of the Use of Gamified Online Tools: A Study with Kahoot and Quizizz in the Educational Context. *International Journal of Information and Education Technology*, *14*(1), 132–140. https://doi.org/10.18178/ijiet.2024.14.1.2033

Marsa, C., Kuspiyah, H., & Agustina, E. (2021). The Effect of Kahoot! Game to Teaching Reading Comprehension Achievement. *Journal of English Teaching*, *7*(2), 133–149. https://doi.org/10.33541/jet.v7i2.2738

Maulida, N. D., Sudirman, N. A., & Munawaroh, N. T. (2024). The effect of quizlet application towards students' vocabulary mastery at the Eighth Grade of SMP-IT Mathla'ul Anwar Malingping Lebak, Banten in the Academic Year 2023/2024. *Journal of Contemporary Issues in Primary Education*, *2*(1), 78–78. https://doi.org/10.61476/ydmeaf82

Metwally, A. H. S., Nacke, L. E., Chang, M., Wang, Y., & Yousef, A. M. F. (2021). Revealing the hotspots of educational gamification: An umbrella review. *International Journal of Educational Research*, *109*(5), 101832. https://doi.org/10.1016/j.ijer.2021.101832

Moore-Russo, D., Wiss, A., & Grabowski, J. (2017). Integration of Gamification into Course Design: A Noble Endeavor with Potential Pitfalls. *College Teaching*, *66*(1), 3–5. https://doi.org/10.1080/87567555.2017.1295016

Munuyandi, T., Husain, S., Azidan, M., Jabar, A., & Jusoh, Z. (2021). Effectiveness Of Quizizz in Interactive Teaching and Learning Malay Grammar. *Asian Journal of University Education*, *17*(3). https://doi.org/10.24191/ajue.v17i3.14516

Niyi Jacob , O., Edinoh, K., & Ewhe, P. O. (2024). A Review Study on Reasons for Large Class Sizes in Tertiary Institutions in Nigeria. *Jurnal Pendidikan Non Formal*, *1*(3), 12–12. https://doi.org/10.47134/jpn.v1i3.293

Ofosu-Ampong, K. (2020). The Shift to Gamification in Education: A Review on Dominant Issues. *Journal of Educational Technology Systems*, *49*(1), 113–137. https://doi.org/10.1177/0047239520917629

Okkan, A., & Aydin, S. (2020). The Effects of the Use of Quizlet on Vocabulary Learning Motivation. *Language and Technology*, *2*(1), 16–25. https://dergipark.org.tr/en/pub/lantec/issue/52176/662861

Pertiwi, A. P. (2020). Using the Quizizz as an assessment of students' English Learning. *Journal of English Teaching, Applied Linguistics and Literatures (JETALL)*, *5*(1), 37-44.

Pitoyo, M. D., Sumardi, S., & Asib, A. (2020). Gamification-Based Assessment: The Washback Effect of Quizizz on Students' Learning in Higher Education. *International Journal of Language Education*, *4*(2), 1. https://doi.org/10.26858/ijole.v4i2.8188

Platzer, H. (2020). The role of Quizlet in vocabulary acquisition. *Electronic Journal of Foreign Language Teaching*, *17*(2).

Priyanti, N. W. I., Santosa, M. H., & Dewi, K. S. (2019). Effect of Quizizz towards the eleventh-grade English students'reading comprehension in mobile learning context. *Language and Education Journal Undiksha*, *2*(2), 71-80. https://doi.org/10.23887/leju.v2i2.20323

Quiroz, M. F., Gutiérrez, R., Rocha , F., Valenzuela, M. P., & Vilches, C. (2021). Improving English vocabulary learning through Kahoot!: A quasi-experimental high school experience. *Teaching English with Technology*, *21*(2), 3–13.

Ramadani, T. H. S. A., Fajria, L. S., & Fitria, S. (2021). Quizizz as Distance Learning Tool: Effects and Students' Opinion. *JournEEL (Journal of English Education and Literature)*, *3*(2), 60-70. https://doi.org/10.51836/journeel.v3i2.261

Sera, L., & Wheeler, E. (2017). Game on: The gamification of the pharmacy classroom. *Currents in Pharmacy Teaching and Learning*, *9*(1), 155–159. https://doi.org/10.1016/j.cptl.2016.08.046

Shyr, W. J., Hsieh, Y. M., & Chen, C. H. (2021). The effects of peer-based instant response system to promote learning performance, intrinsic motivation and self-efficacy. *Sustainability*, *13*(8), 4320. https://doi.org/10.3390/su13084320

Sippel, L. (2022). Quizlet. *CALICO Journal*, *39*(3), 393-402. https://doi.org/10.1558/cj.19888

Wahyumunika, N. L. P., Ratminingsih, N. M., & Suprianti, G. A. P. (2021). The use of TPS strategy combined with Kahoot! In teaching reading. *Language and Education Journal Undiksha*, *4*(1), 32-38.

Wang, A. I., & Tahir, R. (2020). The effect of using Kahoot! for learning–A literature review. *Computers & Education*, *149*, 103818.

Yüksel, H. G., Mercanoğlu, H. G., & Yılmaz, M. B. (2022). Digital flashcards vs. wordlists for learning technical vocabulary. *Computer Assisted Language Learning*, *35*(8), 2001-2017.

Yulianto, I., Warsono, W., Nasution, N., & AP, D. B. R. (2020). The effect of learning model STAD (Student Team Achievement Division) assisted by media Quizizz on motivation and learning outcomes in class XI Indonesian History Subjects at SMA Trimurti Surabaya. *International Journal for Educational and Vocational Studies*, *2*(11).

Zhao, F. (2019). Using Quizizz to integrate fun multiplayer activity in the accounting classroom. *International Journal of Higher Education*, *8*(1), 37.

Zuhara, N. R., Supardi, K. I., & Susilaningsih, E. (2020). The effect of the problem -based learning model using Quizizz evaluation on students cognitive science learning outcomes in elementary school. *Journal of Primary Education*, *9*(4), 364–376. https://doi.org/10.15294/jpe.v9i4.40752

TEACHERS' CAPACITY BUILDING ON INTELLIGENT TUTORING SYSTEM FOR INSTRUCTIONAL DELIVERY IN TECHNICAL COLLEGES IN KWARA STATE

TAIWO, S. A., AKINDELE, N. A., OWODUNNI, A. S.
Department of Educational Technology, Faculty of Education, University of Ilorin, Kwara State, Nigeria
Corresponding Author Email Address: akindele.na@unilorin.edu.ng GSM: 08023256607

Abstact
Education is a fundamental driver of both individual and national development, with its success closely tied to the quality of instruction delivered. In technical colleges within Kwara State, Nigeria, conventional teaching approaches still dominate the classroom, resulting in low student engagement and learning outcomes that often fail to address the diverse needs of learners in today's technology-driven world. The use of Intelligent Tutoring Systems (ITS) AI-powered, computer-based platforms that deliver personalized, adaptive instruction presents a promising solution to enhance the teaching and learning process. These systems mimic the benefits of one-on-one tutoring by tailoring lessons to each student's learning pace and style. Despite their potential, the use of ITS in Nigerian technical education is still minimal. Many educators are not sufficiently informed, trained, or confident in using such technologies. Furthermore, gender differences play a role in the adoption of digital tools, with female teachers frequently facing limited exposure and lower confidence, thereby restricting inclusive technological progress in classrooms. This research seeks to evaluate both the awareness and level of ITS integration among male and female teachers in technical colleges across Kwara State. It also examines whether gender significantly influences teachers' awareness and integration of ITS in lesson planning and instructional practices. Employing a descriptive survey design, the study gathered data using structured questionnaires distributed to a stratified random sample of teachers. The data were analyzed using both descriptive and inferential statistical methods. The findings are expected to guide gender-sensitive training initiatives and support policy changes aimed at ensuring fair and inclusive access to educational technologies within technical education.

Keywords: Intelligent Tutoring Systems, Capacity Building, Technical Colleges, Gender Disparity, Educational Technology, Teaching Effectiveness

Introduction
Education remains the foundation for societal advancement, with teaching and learning serving as its core components. The effectiveness of instructional delivery plays a crucial role in fostering students' understanding, critical thinking abilities, and lifelong learning habits. Among the various educational sectors, technical and vocational education holds particular importance as it contributes significantly to economic development by equipping learners with hands-on skills needed across industrial fields. The quality and relevance of this form of education largely depend on the adoption of effective pedagogical approaches and the integration of modern instructional technologies. Yet, in many technical colleges in Nigeria and particularly in Kwara State, teaching practices are often outdated, teacher training is insufficient, and the use of technology in classrooms remains minimal [1].

These persistent challenges have negatively impacted student performance, reduced classroom engagement, and contributed to a widening skills gap in the labor market. One promising strategy to combat these issues is through teacher capacity building an approach

focused on enhancing teachers' knowledge, competencies, and access to educational resources for effective modern teaching [2]. This strategy emphasizes continuous professional growth and responsiveness to evolving trends in education. In technical education, capacity building should especially prioritize training in Information and Communication Technology (ICT), particularly tools that encourage interactive, student-centered, and adaptive learning. A notable innovation in this context is the Intelligent Tutoring System (ITS), a computer based tool driven by artificial intelligence to provide personalized instruction tailored to each student's unique learning needs.

Intelligent Tutoring Systems are capable of assessing prior knowledge, tracking learning progress, delivering instant feedback, and modifying instructional content in real-time to suit individual learning paces [3]. Research shows that ITS can, in some cases, rival the effectiveness of human tutors, particularly in technical fields that demand repetition, accuracy, and logical problem-solving [4]. Despite their potential to transform technical education, the level of awareness and implementation of ITS in Nigeria remains low [5]. Many teachers are either unaware of such systems or are ill-equipped to incorporate them into their teaching. Gender dynamics further exacerbate this issue, as female teachers frequently encounter cultural and systemic obstacles that hinder their participation in digital learning initiatives [6]. These obstacles often manifest in reduced self-confidence, limited access to ICT, and lower enrollment in professional development programs.

To effectively address these gaps, there is a pressing need for structured and inclusive capacity-building programs that empower both male and female teachers to integrate ITS into their instructional practices. Such initiatives should not only deliver technical skills training but also raise awareness about the benefits of ITS in supporting individualized learning, increasing teaching efficiency, and enhancing student engagement. Crucially, these programs must adopt a gender-sensitive approach to ensure equitable access and participation. In Kwara State, where the digital shift in education is still in its infancy, these interventions are especially critical. Many schools continue to grapple with poor digital infrastructure and irregular or outdated professional training for teachers [5]. Equipping teachers with skills to effectively use Intelligent Tutoring Systems (ITS), the initiative fosters inclusive education by addressing diverse student learning needs through personalized instruction. It supports sustainable development by integrating advanced technology that enhances teaching quality and learning outcomes in technical education. In addition, this capacity-building effort strengthens teacher preparation, ensuring educators are adept at modern, data-driven instructional practices. Globally, it contributes to a more equitable and innovative educational ecosystem, preparing students for future technological demands.

Empowering teachers with the skills to utilize ITS can result in more data-informed, responsive teaching strategies and foster a more inclusive and engaging learning environment. As Nigeria aligns itself with global educational goals particularly the United Nations Sustainable Development Goal 4 (SDG 4), which advocates for inclusive and equitable quality education integrating ITS into teaching practices becomes essential [7]. This integration not only improves instructional delivery but also better equips students to succeed in an increasingly technology-driven world [8].

Given these considerations, this study explores the level of awareness and integration of Intelligent Tutoring Systems among teachers in technical colleges in Kwara State, with an emphasis on gender-based differences. It also seeks to assess the role and impact of capacity-building initiatives in enhancing teaching effectiveness through the use of ITS. Identifying current limitations and proposing targeted strategies, this research aims to contribute to ongoing efforts in educational reform and digital equity within Nigeria's technical education sector.

Intelligent Tutoring Systems have gained recognition as one of the most promising tools in educational technology. These AI-powered platforms offer adaptive and personalized learning experiences that simulate the functions of a human tutor. Evaluating students' strengths, weaknesses, and progress in real time, ITS can provide tailored feedback and adjust instructional materials accordingly [9]. Numerous empirical studies affirm their effectiveness, particularly in STEM subjects, where guided instruction and problem-solving are crucial. However, despite their proven benefits, ITS integration into classroom instruction remains limited, especially in developing regions. Olawale and Salawu (10) attribute this to low awareness levels, inadequate teacher training, and infrastructure deficits.

Their findings indicate that many teachers in sub-Saharan Africa lack both the familiarity with ITS concepts and access to the professional development needed for effective implementation. This digital divide reinforces the continued reliance on traditional, less effective teaching methods, even in settings like technical and vocational education where ITS could make a substantial difference. Gender is another critical factor affecting technology adoption in education. Okonkwo and Uzoegwu (11) highlight that male teachers are generally more inclined to adopt digital tools than their female counterparts, a difference linked to disparities in ICT exposure, confidence, and societal expectations that limit women's participation in technical domains. In technical colleges where digital proficiency is essential, this gender imbalance further complicates the adoption of educational innovations like ITS. Without intentional efforts to foster inclusivity, the integration of such technologies risks deepening existing inequalities within the teaching workforce.

To overcome these challenges, capacity-building has been widely endorsed by global organizations and education specialists. According to the World Bank [12], effective capacity-building extends beyond occasional workshops, encompassing ongoing professional development, experiential learning with technology, and strong institutional backing. These programs should be context-specific, addressing the unique barriers educators face within their respective environments. Additionally, incorporating gender-inclusive frameworks is vital to ensure that both male and female teachers are equally empowered to engage in the digital transformation of education.

Despite the growing body of global research on ITS and teacher development, there is limited scholarly focus on technical colleges in Nigeria. Even fewer studies have examined how ITS is being introduced, adopted, or supported in Kwara State's technical education landscape. Much of the existing literature centers on general or university education, leaving vocational institutions largely overlooked. This gap hampers our understanding of how ITS can be effectively implemented in technical settings and how capacity-building strategies can be designed to address region-specific and gender-related challenges. Therefore, this study seeks to bridge this knowledge gap by investigating the current state of ITS awareness, usage, and integration in Kwara State's technical colleges, while also exploring the influence of gender and the effectiveness of capacity-building initiatives on instructional delivery.

Statement of the Problem

Technical colleges serve a crucial function in preparing students for the labor market by equipping them with practical, industry-aligned competencies. In a world increasingly shaped by digital innovation, effective instructional delivery within these institutions is critical to both student achievement and national development. Yet, in many technical colleges across Kwara State, outdated, teacher-centered methods still dominate classroom instruction. These methods often fail to address diverse learner needs or integrate technological advancements, resulting in low student engagement, minimal interactivity, and poor learning outcomes.

One technological innovation with the potential to address these issues is the Intelligent Tutoring System (ITS). ITS platforms employ artificial intelligence to deliver customized

instruction and instant feedback, allowing learners to progress at their own pace while receiving targeted support. Despite these advantages, ITS remains underutilized in Kwara State. Many teachers lack awareness of these tools or the technical know-how to use them effectively. Gender inequality further compounds the situation. Female teachers often face greater barriers to digital literacy and professional development due to societal norms, limited access to ICT training, and lower confidence in using technology.

These challenges underscore the urgent need for structured capacity-building programs aimed at improving teachers' understanding, competence, and confidence in using ITS. Without such targeted intervention, the disconnect between conventional teaching approaches and modern educational expectations will persist undermining the quality of technical education and preventing both teachers and students from fully benefiting from digital learning innovations. Hence, this study seeks to bridge the gap by investigating the current state of ITS awareness, usage, and integration in Kwara State's technical colleges, while also exploring the influence of gender and the effectiveness of capacity-building initiatives on instructional delivery.

Purposes of the Study

1. To examine the level of awareness of Intelligent Tutoring Systems among male and female teachers in technical colleges.
2. To evaluate the extent of integration of Intelligent Tutoring Systems into lesson planning and subject teaching among teachers in technical colleges.

Research Questions

1. What is the level of awareness of Intelligent Tutoring Systems among teachers in technical colleges?
2. To what extent are Intelligent Tutoring Systems integrated into lesson plans and subject teaching in technical colleges?

Research Hypotheses

1. H_{01}: There is no significant difference in the awareness of teachers on Intelligent Tutoring Systems based on gender.
2. H_{02}: There is no significant difference in the integration of Intelligent Tutoring Systems into lesson plans and teaching of subjects in the classroom based on gender.

Significance of the Study

The result of the study would be of great benefit to the following stakeholders: the National Board for Technical Education (NBTE), curriculum designers, educational technologists, students, teachers, industries, parents, and future researchers.

The findings would provide **National Board for Technical Education** (NBTE) with empirical data on the effectiveness of Intelligent Tutoring Systems (ITS) in improving instructional delivery. This insight can guide policy formulation and national strategies for integrating ITS in technical education, fostering innovation and quality assurance in teaching and learning processes.

The study might offer valuable information to curriculum designers on how ITS can be embedded effectively within existing and future curricula. It will highlight key areas where digital intelligence can complement conventional instructional approaches, ensuring that curricula remain relevant to current technological advancements and industry demands.

Educational technologists could benefit by gaining a clearer understanding of the practical applications and limitations of ITS in technical college settings. The study will inform the development of more effective tools, platforms, and instructional resources that align with teachers' needs and students' learning styles.

For students, the study promises improved learning experiences through personalized instruction, adaptive learning paths, and immediate feedback enabled by ITS. This can enhance their engagement, understanding of complex technical subjects, and overall academic achievement.

Teachers stand to gain significantly from capacity-building initiatives informed by the study's outcomes. Enhanced knowledge and skills in utilizing ITS might empower teachers to deliver more effective, interactive, and differentiated instruction, ultimately improving classroom dynamics and learning outcomes.

Industries could benefit indirectly through the production of more competent and technologically adept graduates. As technical colleges adopt ITS-enhanced teaching methods, students will develop skills that are more aligned with modern industry requirements, thereby improving workforce readiness.

Parents might gain from the improved academic performance and employability of their children. The use of ITS is expected to foster greater student motivation and achievement, which can lead to better career prospects and social mobility, aligning with parents' aspirations for their children's futures.

Future researchers could find this study a valuable reference point for further investigations into ITS in education. It will contribute to the growing body of literature on educational technology and serve as a basis for more nuanced studies exploring different aspects of ITS integration in various educational contexts.

Methodology

The study adopted descriptive survey research design. The study was conducted in all Technical College in Kwara State. The population for the study comprised all teachers in all the Technical College. Purposive sampling technique was used to select 60 teachers for the study. The instrument employed for the collection of data was a questionnaire designed by the researcher. It is titled “Teachers’ Capacity Building on Intelligent Tutoring System for Instructional Delivery Questionnaire”. The instrument was made up of Sections (I and II). Section I elicits teachers personal information while Section II comprise two parts (A & B). Section A was designed to collect data on the awareness level of Teachers on the use of ITS for instructional delivery.

While Section B sought data on level of integrating ITS for instructional delivery, The instrument has a four point response scale of Very Aware (VA), Moderately Aware (MA),

Slightly Aware (SA) Not Aware (NA), similarly, Fully Integrated (FI), Moderately Integrated (Mod I), Minimally Integrated (Min I) and Not Integrated (NI) with assigned weights of 4, 3, 2, and 1 respectively. The instrument was face validated by experts. Cronbach alpha reliability method was used to determine the internal consistency of the item in the questionnaire and the reliability coefficient of .77 was obtained. An indication that the instrument was consistent in measuring what it intended to measure.

The researcher employed the services of two trained research assistants to assist in administering the questionnaire. Respondents were given the instrument to go through and respond to the items on the spot and then collect back after completion. A total of 60 copies of the questionnaire were administered to the respondents. The data collected were analyzed using mean and standard deviation to answer research questions and t-test to test null hypotheses at 0.05 level of significance at relevant degree of freedom, with the applications of Statistical Package for Social Sciences (SPSS).

Results

Research Question1: What is the level of awareness of Intelligent Tutoring Systems among teachers in technical colleges?

Table 1: Level of Awareness of Intelligent Tutoring System among Teachers

S/N	ITEMS	Mean	SD	Remark
1.	I have a foundational understanding of Artificial Intelligence (AI) tools in education.	1.75	0.93	SA
2.	I have participated in professional development workshops or seminars focused on AI in education.	2.63	0.71	VA
3.	I am familiar with the concept and application of AI-powered chatbots in learning environments.	1.68	0.87	SA
4.	I am knowledgeable about software tools used for plagiarism detection in academic settings.	1.70	0.78	SA
5.	I am aware of adaptive learning technologies that personalize instruction based on learner data.	1.52	0.89	SA
6.	I understand the functionality and role of AI-driven Intelligent Tutoring Systems (ITS).	1.55	0.77	SA
7.	I am familiar with automated grading and assessment systems powered by AI.	1.51	0.81	SA
8.	I have an awareness of educational data analytics platforms for tracking and enhancing learning outcomes.	1.50	0.69	SA
9.	I am conversant with the use of Augmented Reality (AR) technologies in teaching and learning.	1.61	0.67	SA
10.	I am proficient in the use of Learning Management Systems (LMS) for content delivery and learner management.	1.64	0.86	SA
11.	I am informed about AI-supported language learning applications.	2.52	0.80	MA
12.	I have a working knowledge of digital content creation tools used for instructional purposes.	1.65	0.69	
	Grand Mean = 1.76	**SD = 0.79**		

The responses from the questionnaire items in table 1 indicate a generally low level of awareness of Intelligent Tutoring Systems (ITS) among teachers in technical colleges. The data indicates that all the items except item 2 and 11 were moderately aware upon as their response means are less than criterion mean. However, the mean values of item 2 and 11 is greater than criterion mean, an indication that all respondents moderately aware with these items. Also, their grand mean is 1.76 with standard deviation of 0.79. This implies that teachers are slightly aware of ITS tools for instruction.

Research Question2: To what extent are Intelligent Tutoring Systems integrated into lesson plans and subject teaching in technical colleges?

Table 2: Extent of Integration of Intelligent Tutoring Systems into Lesson Planning and Subject Teaching among Teachers

S/N	ITEMS	Mean	SD	Remark
1.	I utilize AI-powered tools to support the development and organization of my lecture materials	2.51	0.87	Mod I
2.	I incorporate AI-based applications to enhance the efficiency and depth of my research activities.	1.24	0.92	NI
3.	I employ AI tools to design, administer, and evaluate student assessments.	1.40	0.76	NI
4.	I generate course materials with the assistance of AI-driven educational technologies.	2.63	0.77	Mod I
5.	I use AI-powered systems to track, analyze, and respond to students' academic performance data.	1.45	0.68	NI
6.	I integrate Augmented Reality (AR) technologies to enrich traditional classroom instruction.	2.35	0.79	NI
7.	I rely on AI-powered plagiarism detection tools to ensure academic integrity in student submissions.	1.68	0.85	NI
8.	I leverage AI applications in the instructional design and development of my course content.	1.46	0.75	NI
9.	I address instructional challenges using AI-driven tools such as ChatGPT for real-time problem-solving.	1.32	0.83	NI
10.	I employ AI-powered platforms to create engaging and dynamic educational content during lectures.	1.44	0.81	NI
11.	I use AI-assisted technologies to design and enhance my lecture presentations effectively.	1.76	1.06	NI
	Grand mean = 1.75	**SD = 0.83**		

In Table 2, the responses show a low integration of ITS into lesson plans and classroom teaching among male teachers. It reveals that the respondents not integrated with all the items except item 1 and as they had response means less than the criterion mean. Items 1 and 4 were moderately integrated upon as they had response means more than the criterion mean. The grand mean is 1.75, with a standard deviation of 0.83. This result implies that the teachers do not integrate ITS tools in their instruction.

Hypothesis 1: There is no significant difference in the awareness of teachers on Intelligent Tutoring Systems based on gender.

Table 3: Independent Samples t-test on Teachers' Awareness of ITS based on Gender

Group	N	Mean Awareness Score	SD	t-value	df	p-value	Decision
Male	43	1.92	0.79	2.21	58	0.031	Reject H_{01} (Significant)
Female	17	1.75	0.69				

In Table 3, the independent samples t-test was conducted to determine whether there is a significant difference in the awareness of Intelligent Tutoring Systems (ITS) among teachers based on gender. Results in Table 3 show that male teachers had a higher mean awareness score (M = 1.93, SD = 0.79) compared to their female counterparts (M = 1.75, SD = 0.69). The calculated t-value was 2.21 with 58 degrees of freedom, and the corresponding p-value was 0.031, which is less than the 0.05 level of significance. Based on this result, the null hypothesis (H_{01}) is **r**ejected.

Hypothesis 2: There is no significant difference in the integration of Intelligent Tutoring Systems into lesson plans and teaching of subjects in the classroom based on gender.

Table 4: Independent Samples t-test on Integration of ITS into Teaching Based on Gender

Group	N	Mean Integration Score	SD	t-value	df	p-value	Decision
Male	43	1.91	0.79	2.45	58	0.017	Reject H_{02} (Significant)
Female	17	1.78	0.69				

In Table 4, an independent samples t-test was performed to evaluate whether gender significantly affects the integration of Intelligent Tutoring Systems (ITS) into lesson plans and classroom teaching among teachers in technical colleges. As shown in Table 4, male teachers reported a higher mean integration score (M =1.91, .SD = 0.79) than female teachers (M = 1.78, SD = 0.69). The **t**-value was 2.45 with 58 degrees of freedom, and the corresponding p-value was 0.017, which is less than the 0.05 significance level. Since the p-value is statistically significant, we reject the null hypothesis (H_{02}). This means there is a significant difference in the integration of ITS into teaching based on gender. The findings suggest that male teachers are more likely to incorporate ITS into their teaching and lesson planning.

Findings and Discussion

The results from research question one indicates that teachers in technical colleges are largely unaware of Intelligent Tutoring System (ITS) tools for instructional purposes. This finding is reinforced by the corresponding hypothesis test, which shows a statistically significant gender difference in ITS awareness, with male teachers demonstrating higher levels of awareness than their female counterparts. This outcome is consistent with previous studies such as that of Okonkwo and Uzoegwu (11), who reported that male educators tend to explore and adopt educational technologies more readily. The implication of this finding is the need for targeted

interventions, especially awareness and professional development initiatives that focus on enhancing female teachers' exposure to and familiarity with ITS tools, to close the gender gap in technology adoption in technical education settings.

Similarly, findings related to research question two reveals that ITS tools are generally not integrated into instructional practices by teachers in technical colleges. The associated hypothesis further confirms a statistically significant gender-based difference in ITS integration, again favoring male teachers. This disparity suggests that male teachers may possess greater confidence or experience with digital technologies, which aligns with earlier research [11], [12] showing that men are often more proactive in adopting ICT tools in technical education environments. These results underscore the need for gender-responsive training programs and institutional support mechanisms that foster equal opportunities for both male and female educators to integrate ITS into their teaching.

Furthermore, the perception of ITS effectiveness appears to correlate with its usage. Teachers who had some experience using ITS in their instructional delivery generally rated it as moderately to highly effective. However, a notable proportion predominantly female teachers marked ITS as "Not applicable," suggesting either a lack of usage or insufficient exposure. This finding emphasizes the urgent need for inclusive, gender-sensitive ITS training and sustained support systems to facilitate equitable adoption and maximize the instructional benefits of these technologies in technical education.

Limitations of the Study

This study provides valuable insights into teachers' capacity building on the use of Intelligent Tutoring Systems (ITS) for instructional delivery in technical colleges in Kwara State, certain limitations must be acknowledged:

1. The study is limited to technical colleges within Kwara State. As such, the findings may not fully reflect the experiences, challenges, and outcomes in other states or regions with different educational infrastructures, resources, or policy environments.

2. Due to logistical and time constraints, the study involved a selected sample of teachers and stakeholders. Although efforts were made to ensure representativeness, the results may not capture the full diversity of perspectives across all technical colleges in the state.

3. The level of prior exposure to and experience with Intelligent Tutoring Systems among participating teachers varied significantly. This disparity may have influenced their perceptions of ITS effectiveness and their capacity-building needs, potentially introducing variability into the findings.

4. The study was conducted within the context of existing technological infrastructure in technical colleges, which may be suboptimal or inconsistent across colleges. The limitations of current ICT facilities may have affected both the implementation of ITS and the teachers' ability to fully engage with the technology during the capacity-building process

5. The duration of the capacity-building interventions may have been insufficient for some teachers to achieve full competence or confidence in using ITS. Long-term impacts and

sustained adoption of ITS could not be comprehensively assessed within the study's timeframe.

6. The field of Intelligent Tutoring Systems is rapidly evolving. The tools and platforms assessed in this study may become outdated or replaced by more advanced systems in the near future. Thus, the relevance of some findings may diminish over time as the technology landscape changes.

Recommendations

Based on the findings of this study, the following recommendations are proposed:

1. Regular Training and Workshops**:** Continuous professional development programs focused on the effective use of ITS should be implemented for all technical college teachers.

2. Gender-Inclusive Policy Formulation**:** Educational policymakers should develop and enforce policies that promote gender equity in access to digital training and technological resources.

3. ITS Awareness Campaigns**:** State education authorities should organize structured campaigns to raise awareness about the relevance and application of ITS in enhancing instructional delivery.

Conclusion

Building teacher capacity for the integration of Intelligent Tutoring Systems in technical education is essential for improving pedagogical effectiveness, promoting personalized learning, and advancing educational equity. The findings from this study provide critical insights into the current levels of ITS awareness and integration among teachers in Kwara State, with a focus on gender-based disparities. These insights reinforce the importance of inclusive, sustained, and context-sensitive professional development strategies that can empower all teachers regardless of gender to leverage technology for more impactful teaching and learning outcomes.

References

Afolabi, A., & Daramola, F. *Technological Integration in Nigerian technical education: Challenges and prospects*. Journal of Educational Development, 18, (2): 45-56. (2021)

UNESCO. *Building Teacher Capacity through ICT*. UNESCO Policy Brief. (2017)

Nkosi, P. & Moyo, T. The Role of Intelligent Tutoring Systems in Advancing African Education. *Journal of Emerging Educational Technologies*, 9, (1): 34–48. (2022)

VanLehn, K. The Relative Effectiveness of Human Tutoring, Intelligent Tutoring Systems, and other Tutoring Systems. *Educational Psychologist*, 46, (4): 197–221. (2011)

Nkosi, T., & Moyo, M. Artificial Intelligence and Education in Africa: A review of ITS. African Educational Technology Review, 16, (3): 33-50. (2022)

UNESCO. *Gender Equality and Digital Learning: Addressing the Divide*. (2022)

UNESCO. *Teacher Capacity Development for Inclusive Education*. Paris: United Nations Educational, Scientific and Cultural Organization. (2017)

Afolabi, M. A., & Daramola, O. M. Challenges of Teaching and Learning in Nigerian Technical Colleges. *Nigerian Journal of Educational Technology*, 14, (2): 55–65. (2021)

Graesser, A. C., et al. *Intelligent Tutoring Systems: Evolution in Education*. AI and Education Review, 10, (1): 25-40. (2018)

Olawale, T., & Salawu, R. *Teachers' ICT Capacity in Nigerian Technical Schools*. *Nigerian Journal of Pedagogy*, 11, (1): 61-72. (2020)

Okonkwo, C., & Uzoegwu, M. Gender Differences in ICT Adoption among Secondary School Teachers. *Journal of Educational Technology Research*, 14, (2): 77-88. (2019)

World Bank. *Digital Skills and Education Reform in Sub-Saharan Africa*. Washington, D.C.: World Bank Publications. (2021)

IMPACTS OF ARTIFICIAL INTELLIGENCE TRAINING AND UPSKILLING FOR INDUSTRIAL TECHNOLOGY EDUCATION LECTURERS' EFFECTIVENESS IN NIGERIA FOR INDUSTRY 4.0 AND BEYOND

[1]Ugwunali Yannick Chidi, [2]Okorieocha Christopher Ndudi, Ph.D.
[1]ugwunali.yannick@mouau.edu.ng; [2]okorieocha.chris@mouau.edu.ng.
[1]08100345543; [2]08037629464
[1,2]Department of Industrial Technology Education,
Michael Okpara University of Agriculture, Umudike Abia State.

Abstract

This study focused on the impacts of Artificial Intelligence training and upskilling for Industrial Technology Education lecturers' effectiveness in Nigeria for industry 4.0 and beyond. Two research questions and two hypotheses guided the study. The study adopted a descriptive survey design. Population for the study was 55 respondents comprising 45 male lecturers and 10 female lecturers in the Departments of Industrial Technology Education in Michael Okpara University of Agriculture, Umudike Abia state and Technical Education in Ignatius Ajuru University of Education, Rivers State. No sampling was employed as the population was manageable in size. A 54 item structured questionnaire titled: Lecturers' Effectiveness and Artificial Intelligence Questionnaire (LEAIQ) was used to collect data for the study. The instrument was validated by two experts from the department of ITE and one expert from Measurement and Evaluation unit in the department of Science Education all in Michael Okpara University of Agriculture, Umudike Abia State. A reliability coefficient of .86 was obtained using Cronbach Alpha formula. Mean and standard deviation were used to answer the research questions while t-test was used to test the hypotheses at .05 level of significance. Findings of the study revealed while ITE lecturers demonstrated high effectiveness in teaching activities, their effectiveness in research outputs and academic productivity was relatively low. The study also identified essential AI skills necessary for enhancing lecturers' effectiveness, including computing, programming, machine learning, data analytics, and natural language processing skills. Furthermore, no significant gender-based differences were found in the lecturers' effectiveness or perceived AI skill requirements. This study recommends targeted AI capacity-building programs, curriculum reforms, and continuous professional development to bridge the identified skill gaps and improve lecturers' overall effectiveness.

Keywords: Artificial Intelligence, Industry 4.0, Industrial Technology Education, Lecturers' Effectiveness, Nigeria

Introduction

The education sector in addition to other global sectors is currently undergoing a remarkable revolution due to the emergence of the fourth industrial revolution, popularly known as Industry 4.0. This revolution is marked by the introduction of innovative technologies such as the Internet of Things, artificial intelligence, cloud computing, and cellular communication into various sectors (Singh *et al.,* 2025). The transformative value of Industry 4.0 lies in its ability to integrate digital and physical systems, driving unique efficiency and innovation across industries (Khan & Emon, 2025). This highlights the multifaceted role of Industry 4.0 as it cuts across various sectors including education. Ghobakhloo et al. (2025)

noted that the digital transformation under Industry 4.0 involves the collective implementation of innovative digital technologies, such as augmented reality, Artificial Intelligence (AI), big data analytics, cloud computing, block-chain, Internet of Things (IoT), robotic systems, and simulation tools, across several value systems. From the forgoing, it could be noted that artificial intelligence is one of those innovative technologies arising from Industry 4.0

Artificial Intelligence (AI) has been a trending concept of interest by several researchers in diverse fields including education. AI is a broad field of computer science that involves the development of intelligent computers capable of carrying out tasks that require human intelligence (Slimi, 2023). According to Ergen as cited in Almasri (2024), AI is a vast field involving innovative technologies that have been developed over the past 50 years to enable machines perform tasks traditionally requiring human intelligence, such as perceiving, reasoning, learning, and interacting. Okorieocha and Ugwunali (2025) see Artificial intelligence as a tool created to enhance human capabilities and not to replace them. Therefore, AI is a multifaceted concept that cuts across various sectors that involves computers assisting humans in carrying out complex tasks. Thus, with the help of AI, computers try to solve problems by carrying out intelligent tasks meant to be done by human beings. As the world keeps advancing technologically, the education sector has not been left behind as these global innovations have impacted education recently.

Education could be referred to as the process of imparting knowledge, attitudes, values, and skills to individuals with the aim of empowering them to be useful to themselves and their society. It is a training that involves inculcating knowledge in individuals that will guide them towards self-actualisation and help develop their potentials and innate abilities for the overall development of their nation. It is often popularly noted that no nation can indeed grow above the education of its citizens. In addition, education empowers most individuals to be self-reliant and employable, having valuable services to render to their society. One specific form of education that gainfully empowers people with such skills of self-reliance is Technical and Vocational Education and Training (TVET).

Technical Vocational Education and Training (TVET) is a special form of given to individuals to impart in them necessary skills, values, attitudes and knowledge to enable them become self-reliant (Okorieocha & Ugwunali, 2025). TVET is designed to tackle the challenges of the manpower thereby fostering economic growth and industrial development (Jamaludin *et al.,* 2023). The Federal Republic of Nigeria (FRN) (2013), describes TVET as an all-inclusive term dealing with those aspects of the educational process involving in addition to general education, the study of related sciences and the acquisition of practical skills and values related to occupations in various sectors of economic and social life. Therefore, TVET is very important in empowering individuals with the skills needed them to be employed and also contribute to the economic development of their country. Some of the main academic disciplines under TVET are; Industrial Technology Education, Agricultural Science Education, Home Economics Education, and Business Education among others.

Industrial Technology Education (ITE) is a very important and integral part of TVET. It is a formal and well organised area of study offered in various Nigerian universities, polytechnics and colleges of education. Okorieocha and Ugwunali (2025) referred to ITE as that part of education involving the acquisition of practical skills in various technological areas as well as basic scientific knowledge, attitude and values. According to Ochogba and Isiodu (2024), ITE is an academic programme introduced in the Nigerian education system to help in transferring skills from one generation to another. Anametemfiok & Oluwafemi (2024) see ITE as type of education aimed at inculcating relevant practical skills in individuals as well as contributing to industrial development. The philosophy behind ITE is the development human resources directed towards a national pool of skilled and self-reliant craftsmen, technicians and

technologists in technical and vocational education fields (FRN, 2013). Thus, ITE is designed to produce skilled graduates in relevant technical areas that are expected to be useful to themselves and also contribute to the manpower needs and boost economic development of the nation.

Industrial Technology Education as a course of study offered in most Nigerian Universities is expected to contribute its own quota to the country's technological development by expanding their programmes so as to provide for the manpower needs of the country's diverse economic sectors (Udoudo & Udoetuk, 2020). Consequently, ITE is made up of five specific areas of specialisation. These areas include; Automobile Technology, Building Technology, Electrical/Electronic Technology, Metalwork Technology, and Woodwork Technology. ITE is taught by lecturers who have been trained in the respective areas to meet the aims and objectives of the programme and the overall goals of education in Nigeria. Therefore, with the significant global transformation today due to the advent of Industry 4.0, it is quite necessary that Nigerian ITE lecturers ethically incorporate AI into their teaching methodologies to prepare ITE students for the globally evolving job market. However, this can be attainable if the lecturers undergo further training and upskilling.

Training could be referred to as the experience, knowledge, values, and skills obtained by an individual. Training is a period of undergoing practical experience or instruction in an individual's professional career (Merriam Webster, 2025). Training according to Gupta (2023) is the process of providing individuals with the skills, tools, and expertise they need to do their jobs efficiently, incorporate developments in technology and procedures, and positively contribute to the growth and success of their organisations. Consequently, training is aimed at making and individual competent for a particular role, task or position. However, following the recent technological advancements that have emerged in the education sector such as AI and big data analytics, it is necessary that ITE lecturers who have already undergone relevant training in their various respective areas of specialisation undergo upskilling to enable them meet up with current realities in the sector.

Upskilling refers to the act of providing an individual with more advanced skills often through extra training and education. Gupta (2023) defines upskilling as the process by which employees learn new skills and acquire relevant knowledge and expertise needed for their current work environments and in the nearest future. It concentrates on improving employees' skills, particularly through constant training programs, to assist them progress in their careers. Upskilling could also imply learning new skills or improving on the existing ones in order to stay abreast with latest improvements in technology and changing employment demands within the same field of work. Gupta (2023) emphasized that upskilling mostly concentrates on career advancement instead of change, with a focus on increasing employees' proficiency, efficiency, and value in their existing role. According to Wirnani et al. (2024), upskilling focuses on developing existing skills to accommodate changes and new technologies. Such recent technologies include AI, Internet of Things and big data analytics among others which have impacted on several sectors including education.

Impact refer to the positive or negative changes of a development intervention on its surroundings and the various components that influence development (Australian Department of Foreign Affairs & Trade Office of Development Effectiveness as cited in Hearne & Buffardi, 2016). The United Nations Development Group [UNDG], 2015 referred to impact as the changes in the lives of individuals, including changes in knowledge, skill, behaviour, health, or living conditions for children, adults, families, or communities as a result of a development initiative or action, directly or indirectly, intended or unintended. Consequently. AI has brought about tremendous changes in education as reported by several researchers

(Almasri, 2024; Slimi, 2023). Thus, for the purpose of this study, impact is referred to as the change or results brought about by a programme, in this case, AI.

The impact of AI on education is transformative and multifaceted (Vieriu & Petrea, 2025). Thus, ITE lecturers should be upskilled to enable them perform satisfactorily as professionals in their various areas of specialisation as AI can improve lecturers' effectiveness. Lecturer effectiveness is a critical element in ensuring the quality of teaching, research, and other academic contributions (Cindrakasih *et al.*, 2024). Thus, the productivity of lecturers in Higher Institutions can significantly impact their teaching activities, research, community services and also the quality of graduates they produce.

Lecturer effectiveness is the degree to which teaching staff successfully carryout their duties which include; teaching, research and community service (Adebayo, 2024). Teaching entails planning and delivering lectures, assessing students through tests and examinations, supervising students in industrial training and teaching practice, and final year project supervision. Other responsibilities include developing creative teaching methods, consulting with students, and providing students with relevant educational content and resources. Research includes conducting studies in identified problems, presenting the outcomes of such studies at conferences/seminars, and publishing the results in journals or textbooks. Community service entails providing services to both the school and the community at large. These services include but are not limited to; leading a department, college, committee, external examiner, staff adviser to student societies, and serving other recognised committees at the departmental, faculty, and university levels, such as sports, matriculation, and convocation (Agbionu *et al.*, 2018).

Lack of AI knowledge among lecturers is a crucial challenge to AI adoption as many lecturers who may not have an in-depth understanding of AI find it difficult to incorporate these tools into their instruction (Adebakin, 2025). In this global era of technological advancement, lecturers are expected to be proficient in using a variety of these tools to improve their effectiveness in teaching, research and even community services. Cleopas (2023) opined that AI is one of the rapidly increasing technologies that can improve lecturers' performance. Some impacts of artificial intelligence to lecturer effectiveness in education include; capacity to monitor students' works, monitor performance and learning progress, special education for special learners, acts as interface between students and lecturers, enables students to access relevant knowledge that improve and facilitate teaching and learning; it helps to assess lecturers' works, reduces lecturers' workload and stress; it encourages group and collaborative learning, saves time and enhances lecturer performance which ensures efficiency and higher quality delivery in education (Adebayo, 2024; Cleopas, 2023; Chukwu, 2021). This indicates the numerous impacts of AI in education which could be attainable by ITE lecturers if they are trained and upskilled with Artificial intelligence skills which can improve their efficiency in discharging their professional duties

It is important for ITE lecturers to acquire AI skills to help them effectively discharge their teaching, research and community service roles. AI skills include a wide variety of competencies, ranging from technical expertise to socio-emotional abilities. Technical Skills are the foundational skills required to develop and work with AI systems. They include programming languages such as Python, R, and Java, as well as expertise in machine learning, natural language processing, and data analysis (El-Hadi, 2022; Organisation for Economic Cooperation and Development, 2023). Further, Sneha and Raja (2019), and El-Hadi (2022) argued that data Science Skills are very crucial for lecturers as data is the fuel for AI systems. According to them, skills in data collection, cleaning, and analysis are essential for training AI models and making data-driven decisions.

Another important AI skill is critical thinking and problem-Solving. ITE lecturers should have the ability to think rationally and proffer solutions to challenges in their field. Giraud et al. (2022) posited that AI systems rely on human oversight to ensure ethical and effective decision-making. Thus, critical thinking and problem-solving skills are crucial for designing and implementing AI solutions that align with human values (Kumar, 2023). Similarly, AI technologies can enhance human creativity by automating routine tasks and providing new tools for creative expression (Trisnawati *et al.,* 2023). Therefore, ITE lecturers should imbibe creativity which is essential for working with AI applications.

Collaboration and communication skills are vital for working effectively with both humans and machines (Kumar, 2023). ITE lecturers should be possess good communication skills and should be able to collaborate effectively in their various working environments. Furthermore, as AI becomes more integrated into society, ethical considerations such as privacy, bias, and accountability become increasingly important (Sengsri & Khunratchasana, 2024). Thus, ITE lecturers should have a clearer understanding of the ethical implications of AI to help them apply its tools efficiently and also discharge their duties effectively.

Artificial intelligence training and upskilling is very important for ITE lecturers as they have crucial roles to play towards teaching, research, and community service. Consequently, ITE lecturers should be trained and upskilled to integrate AI ethically and effectively into their teaching and research, as well as to use technology as a means of improving human abilities and obtaining improved educational outcomes. Lecturers are therefore expected to maintain their roles as masters in their respective fields instead of servants, facilitators in instructional delivery, and to positively utilise the multifaceted benefits and prospects of AI for the welfare of individuals while reducing the challenges it presents to our society. Considering the technological advancements in education coupled with the need for lecturers to align with current global practices related to effective teaching, research, and community service as required, there is an urgent need to examine the impacts of artificial intelligence training and upskilling for industrial technology education lecturers' effectiveness in Nigeria for industry 4.0 and beyond. It is based on this background that this study becomes imperative.

Statement of the Problem

The Federal Republic of Nigeria (2013) emphasizes that the goals of Industrial Technology Education are; to develop a skilled workforce, promote technological innovation, equip individuals with practical skills for both employment and self-reliance, and contribute to the nation's industrial and economic growth. Moreover, building solid technological skills by ITE lecturers is important for incorporating technology into teaching and making sure students are well-prepared for the digital age. Nigerian universities offering ITE programmes are therefore expected to train individuals in line with these goals. Thus, Universities' performances and actions towards attaining the goals of ITE as stated above may be attributed to the extent of lecturers' effectiveness.

However, despite the several positive impacts AI in education, ITE lecturers in Nigerian universities are still struggling to fully integrate AI in their academic and research activities (Nannimet *et al.,* 2018; Onah *et al.,* 2020; Thomas *et al.,* 2024). This issue has led to low effectiveness in lecturers towards discharging their official duties. This problem could be attributed to lack of AI training and upskilling in the effective and ethical application of these tools available in education.

This problem of low level of lecturer effectiveness as regards teaching and research if not urgently addressed could lead to poor quality of university education and lack of global recognition, production of half-baked graduates who may lack employability skills, high rate of graduate unemployment, and high risk of insecurity and other societal vices among others. This study therefore seeks to examine impacts of artificial intelligence training and upskilling

for industrial technology education lecturers' effectiveness in Nigeria for industry 4.0 and beyond.

Purpose of the Study

The main purpose of the study is to examine the impacts of Artificial Intelligence training and upskilling for ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond. Specifically, the study seeks to;

1. Examine the extent of ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond.
2. Ascertain the Artificial Intelligence skills for ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond.

Research Questions

1. What is the extent of ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond?
2. What are the Artificial Intelligence skills required for ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond?

Hypotheses

Ho_1: There is no significant difference between the mean responses of male and female ITE lecturers on their level effectiveness in Nigeria for industry 4.0 and beyond.

Ho_2: There is no significant difference between the mean responses of male and female ITE lecturers on the Artificial Intelligence skills for ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond.

Methodology

Descriptive survey research design was adopted for the study. The population for the study comprised 55 respondents consisting 45 male lecturers and 10 female lecturers in the Departments of Industrial Technology Education in Michael Okpara University of Agriculture, Umudike Abia state and Technical Education in Ignatius Ajuru University of Education, Rivers State. The entire population was used since the population was manageable in size. A 54 item structured questionnaire titled: Lecturers' Effectiveness and Artificial Intelligence Questionnaire (LEAIQ) was used to generate data for the study. The instrument was validated by two experts from the department of Industrial Technology Education and one expert from Measurement and Evaluation unit in the department of Science Education all in Michael Okpara University of Agriculture, Umudike Abia State. The reliability of the instrument was estimated by administering copies of the questionnaire to ten (10) ITE lecturers in the Department of Vocational and Technology Education in Rivers State University. The responses were recorded, scored and subjected to Cronbach Alpha Method to determine the reliability coeficient which yielded an internal consistency value of .86. The questionnaire was administered to the respondents using Google forms which ensured automatic recording of the responses. Mean and standard deviation were used to answer the research questions while t-test was used to test the null hypotheses at .05 level of significance. Thus, any item with p-value greater than .05, the hypothesis of no significant difference was upheld at .05 level of significance, but where the p-value is less than .05, the hypothesis of no significant difference was rejected. The data analysis was computed with a computer software programme; statistical package fort the social sciences (SPSS).

Results

Research Question 1

What is the extent of ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond?

Table 1

Mean Scores and Standard Deviation of Male and Female ITE lecturers on their level effectiveness in Nigeria for industry 4.0 and beyond

S/No	Item Statements	Male Lecturers N_1=45		Female Lecturers N_2 = 10		Decision
		X_1	SD_1	X_2	SD_2	
1.	I ensure proper planning before teaching my students	3.71	0.78	3.69	0.88	HE
2.	I strictly adhere to the lecture timetable	2.39	0.82	2.40	0.81	LE
3.	I do not miss my lectures except under situations beyond control	3.48	0.71	3.51	0.70	HE
4.	I give out a comprehensive course outline to the students while introducing each course	2.64	0.71	2.67	0.71	HE
5.	I make students understand the importance of each course I teach them	2.42	0.64	2.41	0.65	LE
6.	I ensure students understand the relevance of each course I teach them to their profession	3.12	0.73	3.15	0.73	HE
7.	I ensure that students comprehend the objectives for each particular lecture	2.65	0.70	2.66	0.71	HE
8.	At the beginning of each topic, I teach students concepts from known to unknown and from simple to complex	1.21	0.80	1.22	0.82	LE
9.	I relate all concepts I teach in the classroom to real life experiences	1.93	0.62	1.99	0.61	LE
10.	I develop and use creative and relevant teaching methods during lectures	1.21	0.74	1.29	0.75	LE
11	I carry out formative evaluation during lectures	2.65	0.70	2.66	0.71	LE
12	I ensure an effective flow of communication with my students during lectures	1.21	0.80	1.22	0.82	LE
13.	I ensure that the instructional objectives for each lecture are achieved	1.93	0.62	1.99	0.61	LE
14.	I ensure that content I teach is updated	2.21	0.74	2.29	0.75	LE
15.	I make use of relevant and current textbooks for teaching	1.93	0.62	1.99	0.61	LE
16.	I deliver all courses allocated to me each semester	1.21	0.74	1.29	0.75	LE
17.	My lectures are very interactive	2.65	0.70	2.66	0.71	HE
18.	I frequently give assignments to my students	2.39	0.82	2.40	0.81	LE
19.	I ensure prompt submission of assignments	1.71	0.78	1.69	0.88	LE
20.	I mark assignments and return to students on time	2.39	0.82	2.40	0.81	LE
21.	I offer revision lectures to students in preparation for examinations	1.48	0.71	1.51	0.70	LE
22.	I set examination questions at the end of every semester	1.64	0.71	1.67	0.71	LE
23.	I ensure that my examination questions adequately cover the content I taught the students	1.42	0.64	1.41	0.65	LE
24.	I invigilate examinations when scheduled	2.12	0.73	2.15	0.73	LE
25.	I mark my students' examination scripts on time	1.65	0.70	1.66	0.71	LE

26.	I submit my students' continuous assessment, examination scores and grades latest two weeks after examinations	1.21	0.80	1.22	0.82	LE
27.	I am always in touch with students as their academic adviser	1.93	0.62	1.99	0.61	LE
28.	I supervise students during their teaching practice	1.21	0.74	1.29	0.75	LE
29.	I supervise students during their industrial training	2.39	0.72	2.41	0.73	LE
30.	I supervise final year students' research projects allocated to me as scheduled	1.48	0.70	1.51	0.72	LE
31.	I conduct research regularly in my area of specialisation	1.64	0.31	1.67	0.34	LE
32.	I regularly present the outcomes of my research at conferences/seminars	2.41	0.48	2.43	0.49	LE
33.	I often publish my research works in relevant journals and textbooks	2.13	0.71	2.16	0.72	LE
34.	I am content with the research works so far conducted by me	1.15	0.79	1.19	0.75	LE
35.	I am satisfied with the articles I have published	1.21	0.78	1.22	0.87	LE
36.	I am content with the chapters I have written in textbooks	1.93	0.82	2.97	0.91	LE
37.	I am happy with the number of textbooks I have authored	2.75	0.79	2.19	0.75	LE
38.	I am satisfied with the papers I have presented at conference	3.21	0.78	1.22	0.87	LE
39.	I often attend AI trainings and workshops	2.93	0.82	2.53	0.91	LE
	Cluster Mean/Standard Deviation	**2.08**	**0.72**	**2.05**	**0.73**	**LE**

Key: X = Mean, SD = Standard Deviation, N = Number, HE = High Extent, LE = Low Extent

The result presented in Table 1 indicates the mean and standard deviation of the responses of both male and female ITE lecturers regarding their extent of effectiveness in Nigeria for industry 4.0 and beyond. The mean scores for the 39 items ranged from 1.21 to 3.71, with a cluster mean of 2.08, indicating a generally low extent of lecturer effectiveness among them. Furthermore, the standard deviation values ranged between .72 and .91, indicating a relatively low dispersion and a high level of agreement among respondents. Based on these findings, it can be inferred that the extent of ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond is low.

Research Question Two

What are the Artificial Intelligence skills required for ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond?

Table 2: Mean scores and standard deviation of responses of male and female ITE lecturers on Artificial Intelligence skills required for lecturers' effectiveness in Nigeria for industry 4.0 and beyond.

S/No	Item Statements	Male Lecturers N_1=45		Female Lecturers N_2 = 10		Decision
		M_1	SD_1	M_2	SD_2	
40.	Technical Skills	2.65	0.81	2.62	0.82	HE
41.	Basic computing skills	3.22	0.74	3.25	0.74	LE
42.	Programming skills such as Python, R, and Java	3.29	0.77	3.21	0.76	HE
43.	Machine learning skills	2.75	0.74	2.81	0.75	HE
44.	Database modelling skills	3.21	0.83	3.11	0.84	LE

45.	Intelligent User Interface (IUI) skills	3.27	0.88	3.14	0.87	LE
46.	Natural Language Processing (NLP) skills	3.16	0.88	3.01	0.87	LE
47.	Data analytics skills	3.18	0.60	3.19	0.61	LE
48.	Data Science skills	3.19	0.76	3.11	0.75	LE
49.	Problem-Solving skills	3.28	0.76	3.11	0.74	LE
50.	Critical thinking skills	3.24	0.76	3.15	0.74	LE
51.	Creativity skills	3.21	0.73	3.25	0.75	LE
52.	Communication skills	3.19	0.81	3.11	0.82	LE
53.	Collaboration skills	3.13	0.74	3.05	0.75	LE
54.	Ethical and social skills	2.61	0.77	2.75	0.36	LE
	Cluster Mean/Standard Deviation	**3.11**	**0.77**	**3.06**	**0.75**	**LE**

Key: M = Mean, SD = Standard Deviation, N = Number, HE = High Extent, LE = Low Extent

Table 2 presents the mean and standard deviation of responses from male and female ITE lecturers on the Artificial Intelligence skills required for ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond. The mean scores for the 15 items ranged from 2.61 to 3.27, with a cluster mean of 3.09, indicating a general acceptance of the items as Artificial Intelligence skills required for ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond. Further, the standard deviation values ranged from .36 to .88, indicating that the responses were relatively consistent and clustered around the mean. Based on these findings, it can be concluded that all the items in the table are Artificial Intelligence skills required for ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond.

Hypothesis One

Ho_1: There is no significant difference between the mean responses of male and female ITE lecturers on their level of effectiveness in Nigeria for industry 4.0 and beyond.

Table 3: Summary of t-test results of mean responses of male and female ITE lecturers on their level of effectiveness in Nigeria for industry 4.0 and beyond.

Hypotheses	Groups	N	X	SD	Df	t	P-value	95% CI	Decision
Ho_1	Male Lecturers	45	2.08	.72	53	.12	.91	-0.48 - 0.54	Accept
	Female Lecturers	10	2.05	.73					

Key: N= Number, X= Mean, SD= Standard Deviation, Df= Degree of freedom, CI= Confidence interval

Table 3 shows the t-test analysis of mean responses of male and female ITE lecturers on their level of effectiveness in Nigeria for industry 4.0 and beyond. Based on the findings presented in the table, it can be observed that at 53 degrees of freedom, the p-value was .91 which exceeded the predetermined significance level of 0.05 for this study. Consequently, the null hypothesis is accepted. This signifies that there is no significant difference between the mean responses of male and female ITE lecturers on their level of effectiveness in Nigeria for industry 4.0 and beyond.

Hypothesis Two

Ho_2: There is no significant difference between the mean responses of male and female ITE lecturers on the Artificial Intelligence skills for ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond.

Table 4: Summary of t-test results of mean responses of male and female ITE lecturers on the Artificial Intelligence skills for ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond.

Hypotheses	Groups	N	M	SD	Df	t	P-value	95% CI	Decision
Ho_2	Male Lecturers	45	3.11	.77	53	.19	.85	-0.48 - 0.58	Accept

Female Lecturers	10	3.06	.75

Key: N= Number, M= Mean, SD= Standard Deviation, Df= Degree of freedom, CI= Confidence interval

Table 4 shows the t-test analysis of mean responses of male and female ITE lecturers on the Artificial Intelligence skills for ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond. Findings as shown in the table indicate that at 53 degrees of freedom, the computed p-value was .85, which is greater than the established significance level of.05. As a result, the null hypothesis is accepted. This implies that there is no significant difference between the mean responses of male and female ITE lecturers on the Artificial Intelligence skills for ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond.

Discussion

Findings of the study revealed a low extent of ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond. The respondents revealed that they are not satisfied with; their research outputs so far, the articles they have published, the chapters they have written in textbooks, the number of textbooks they have authored and the papers they have presented at conferences among others. However, the study also revealed that there is a high extent of effectiveness in teaching activities. The finding is in line with that of Adebayo (2024) who also found a low extent of lecturers' job effectiveness in the Ogun State universities. Furthermore, the result of hypothesis one corroborates the findings of research question one given that no significant difference exists in the mean responses of male and female ITE lecturers in on their extent of effectiveness in Nigeria for industry 4.0 and beyond.

Furthermore, the study identified several artificial intelligence skills required for ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond. According to the respondents, key AI skills include: Technical Skills, basic computing skills, programming skills such as Python, R, and Java, machine learning skills, database modelling skills, Intelligent User Interface (IUI) skills, Natural Language Processing (NLP) skills, data analytics skills, data science skills among others. This implies that for lecturers' job effectiveness to be attained using AI, lecturers' need to acquire some specific skills as discussed in this study. These findings align with the study of Odigwe and Owan (2020), which revealed that lecturers' attributes, including computing and language skills, significantly influence their use of ICT tool such as Artificial Intelligence for teaching, conducting research, and managing academic records in higher education. Further analysis indicated that there was no significant difference between the mean responses of male and female ITE lecturers on the artificial intelligence skills for ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond. This indicates that gender does not play a significant role in determining the artificial intelligence skills for ITE lecturers' effectiveness in Nigeria for industry 4.0 and beyond.

Conclusion

The study examined the impacts of Artificial Intelligence training and upskilling on the effectiveness of Industrial Technology Education lecturers in Nigeria for Industry 4.0 and beyond. Findings revealed a generally low level of effectiveness among ITE lecturers in research-related activities such as publications, authorship, and conference presentations, although their teaching effectiveness remains relatively high. Moreover, the study identified a range of essential AI-related skills such as programming, machine learning, data analytics, and natural language processing as critical for enhancing lecturers' effectiveness in adapting to Industry 4.0 demands. Importantly, the study found no significant gender-based differences in perceptions of both job effectiveness and AI skills requirements. This suggests a unified need for capacity development across both male and female ITE lecturers to bridge the digital competence gap and align with global educational and technological standards.

Recommendations

Based on the findings of this study, the following recommendations are made:

1. Government agencies, professional bodies, and university administrators should organize regular AI-focused training and upskilling programs tailored specifically for ITE lecturers to boost their effectiveness in research, teaching, and innovation.
2. Universities offering Industrial Technology Education should integrate essential AI competencies such as data analytics, machine learning, and data science into the curriculum for both pre-service and in-service lecturers.
3. Universities should invest in modern AI-powered tools and infrastructure that support smart teaching, digital research, and automated academic services to foster an AI-ready academic environment.
4. To address the low level of research effectiveness, universities and funding bodies should provide incentives, grants, and mentorship opportunities that encourage lecturers to engage in impactful, AI-driven research and publications.

References

Adebakin, M. A. (2025). AI: A challenge to teaching, research, and community service. Okebukola, P. (Ed), *Handbook on Artificial Intelligence and Quality Higher Education.* Sterling Publishers.

Adebayo, A. A. (2024). Artificial intelligence and lecturers' effectiveness in Ogun state owned universities. *Fuoye International Journal of Business and Economics Education*, 1(1), 188-198. https://fjbeed.fuoye.edu.ng/index.php/public/article/view/27

Agbionu, U. C., Anyalor, M. & Nwali, A. C. (2018). Employee engagement and performance of lecturers in Nigerian tertiary institutions. *Journal of Education and Entrepreneurship*, 5(2), 69-87. https://files.eric.ed.gov/fulltext/ED583751.pdf

Almasri, F. (2024). Exploring the impact of artificial intelligence in teaching and learning of science: A systematic review of empirical research. *Research in Science Education*, 54. 977-997. https://doi.org/10.1007/s11165-024-10176-3

Anametemfiok, L. E., & Oluwafemi, R. A. (2024). Risk factors associated with industrial technical education student's industrial training programme in Enugu. *Industrial Technology Education Research Journal (ITERJ)*, 7(1), 223-232. https://iterj.org/pub/article/view/v-7-n-1-art-18

Borgonovi, F., Calvino, F., Criscuolo. C., Nania, J., Nitschke, J., O'Kane, L., Samek, L., & Seitz, H. (2023). Emerging trends in AI skill demand across 14 OECD countries. *OECD Artificial Intelligence Papers*, 2, 12-64. https://doi.org/10.1787/7c691b9a-en.

Cindrakasih, R., Jahara, J., Soegiarto, I., Ma'sum, H., & Asmuri, A. (2024). Strategy for implementing artificial intelligence in the lecturer performance evaluation system in higher education. *International Journal of Educational Narratives*, *2*(2), 224–234. https://doi.org/10.70177/ijen.v2i2.822

Eko, W., Siti, M., Abdul H., & Pardomuan, P. (2024). Reskilling and upskilling: HR adaptation strategies to digital transformation in the traditional sector. *Jurnal Ekonomi, Manajemen, Akuntansi*, 4(1), 2747–2756. https://doi.org/10.56799/ekoma.v4i1.6237

El-Hadi, M. (2022). Most in-demand artificial intelligence skills to learn in 2022. *Journal of the Egyptian Society for Information Systems and Computer Technology*, 29(29), 74-77. https://doi.org/10.21608/jstc.2022.274474

Federal Republic of Nigeria. (2013). *National policy on education.* NERDC.

Ghobakhloo, M., Iranmanesh, M., Foroughi, B., Tseng, M. L., Nikbin, D., & Khanfar, A. A. A. (2023). Industry 4.0 digital transformation and opportunities for supply chain resilience: A comprehensive review and a strategic roadmap. *Production Planning & Control*, *36*(1), 61-91. https://doi.org/10.1080/09537287.2023.2252376

Giraud, L., Zaher, A. C., Hernandez, S., & Akram, A. A. (2022). The impacts of artificial intelligence on managerial skills. *Journal of Decision Systems*, 32(3), 566-599. https://doi.org/10.1080/12460125.2022.2069537

Gupta, D. (2023). *14 types of employee training programs (+benefits, examples).* https://whatfix.com/blog/types-employee-training-programs/

Jamaludin, R. B., Hamid, A. H. A., & Alias, B. S. (2023). Empowering technical and vocational education and training (TVET). *International Journal of Academic Research in Business & Social Sciences*, 13(12), 3072-3080. https://doi.org/10.6007/ijarbss/v13-i12/20159

Khan, T. & Emon, M. M. H. (2025). Supply chain performance in the age of Industry 4.0: Evidence from manufacturing sector. *Brazilian Journal of Operations and Production Management,* 22(1), 1-17. https://doi.org/10.14488/BJOPM.2434.2025

Kumar, S. (2023). Developing human skills in the era of artificial intelligence: Challenges and opportunities for education and training. *Scholedge International Journal of Multidisciplinary & Allied Studies*, 10(2), 11-19. DOI: http://dx.doi.org/10.19085/sijmas100201

Nannim, A. F. (2018). Investigating the availability and utilisation of ICT teaching facilities in Abubakar Tafawa Balewa University (ATBU), Bauchi. Master's thesis submitted to the Faculty of Technology Education, Abubakar Tafawa Balewa University, Bauchi.

Ochogba, C. O., & Isiodu, B. N. (2024). Influence of policies, politics and ethnicity on implementation of Industrial Technology Education in Nigeria. *African Journal of Humanities and Contemporary Education Research,* 17(1), 206-214. https://doi.org/10.62154/ajhcer.2024.017.010509

Okorieocha, C.N., & Ugwunali, Y.C. (2025). Strategies for improving Industrial Technology Education in universities in south east Nigeria. *Network for Educational Advancement and Development Journal,* 1(1) (In Press).

Onah, J. C., Onyebuchi, G. U., Eke, C. C., Adayi, I. O. (2020). Empirical evidence of availability and utilisation of Information and Communication Technology (ICT) in teaching and learning cultural and creative arts in Nsukka Local Government Area. *Journal of the Social Sciences,* 48(3), 446-464. https://www.researchgate.net/publication/342892265

Sengsri, S., & Khunratchasana, K. (2024). Artificial intelligence competence: A crucial skill for the digital citizens. *International Education Studies*, 17(3), 75-83. https://doi.org/10.5539/ies.v17n3p75

Singh, J., Singh. A., Singh. H., & Doyon-Poulin, P. (2025). Implementation and evaluation of a smart machine monitoring system under industry 4.0 concept. *Journal of Industrial Information Integration,* 43(1), https://doi.org/10.1016/j.jii.2024.100746.

Sneha, S. and Raja, J.B. (2019) A conceptual overview and systematic review of artificial intelligence and its approaches. *International Journal of Emerging Technology and Innovative Engineering,* 5, 821-828. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3519180

Trisnawati, W., Putra, R. E., & Balti, L. (2023). The impact of artificial intelligence in education toward 21st century skills: A literature review. *PPSDP International Journal of Education*, *2*(2), 501–513. https://doi.org/10.59175/pijed.v2i2.152

Udoudo, N. J., & Udoetuk, U. S. (2020). Enhancing vocational skills acquisition among technical education students in tertiary institutions in Akwa Ibom state, Nigeria. *Journal of Educational Realities, JERA,* 10(1), 1-12. https://www.researchgate.net/publication/374350371

United Nations Development Group (2015). *Delivering together for development.* https://www.un.org/en/ecosoc/qcpr/pdf/undg_paper_cip.pdf

Vieriu, A. M., & Petrea, G. (2025). The impact of artificial intelligence (ai) on students' academic development. *Education Sciences*, *15*(3), 343. https://doi.org/10.3390/educsci15030343

MULTIMEDIA INTEGRATION AND ITS IMPACT ON LEARNING IN AND OUTSIDE THE CLASSROOM

***IBIRONKE, Ebenezer Sanya, HASSAN A. M, & ADEROJU, Musiliu Adekola**
Department of Educational Technology, University of Ilorin, Ilorin, Nigeria
*Ibisanya2@unilorin.edu.ng: Aderoju.am@unilorin.edu.ng
*08066987123

Abstract

Multimedia is the integration of text, images, audio, animation, and video elements to enhance instructional delivery. The incorporation of multimedia into educational practices greatly improves the learning experience by making it more engaging, accessible, and effective. As technology advances, the potential for multimedia in education will grow, providing new ways to support learning in various settings. This review examines how multimedia tools are used in education, focusing on their effectiveness in enhancing learning experiences. It emphasizes the value of multimedia elements such as text, images, audio, video, and animations, their appropriateness for different audiences, and their influence on cognitive load. The review also addresses the challenges of multimedia integration and possible solutions. It acts as a guide for educators and administrators to choose suitable multimedia tools and recommends future research to solve remaining issues and explore innovative multimedia approaches.
Keywords: Multimedia Integration, Learning, Human Memory, Knowledge Concretization

Introduction

Multimedia integration in education is transforming learning by strategically using various media such as text, images, audio, and video within educational content. This approach enhances the learning experience, engaging students with different learning styles and improving knowledge retention. As technology advances, educators are employing multimedia tools like videos and interactive applications to foster dynamic learning environments. Recent studies show that this integration not only boosts student engagement and motivation but also cultivates essential 21st-century skills like creativity, critical thinking, and problem-solving techniques (Naluwooza *et al.*, 2023; Alzubi, 2023).

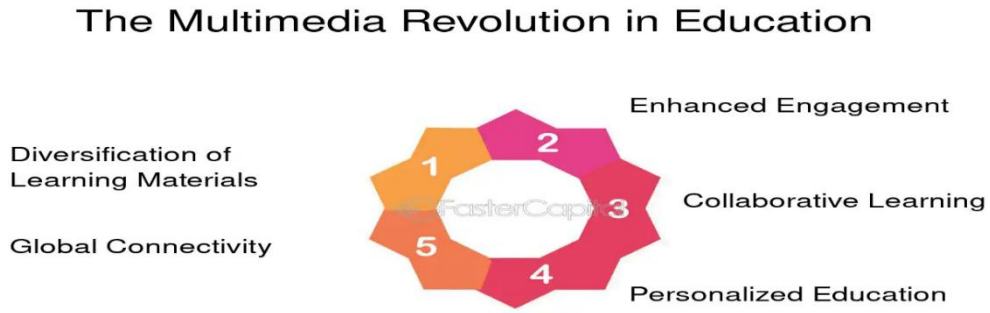
Furthermore, multimedia technologies enhance personalized learning by offering resources that cater to individual preferences, adapting to the blurred lines between formal and informal education (Ismoilovich & Ravshanbekovich, 2023). Such technologies can connect home and school learning environments, promoting flexibility and learning opportunities (Sonnenschein *et al.,* 2021). However, the effective use of multimedia in classrooms faces challenges, including limited technology access, inadequate teacher training, and potential student distractions. As educational institutions evolve with technological changes, it is essential to understand how multimedia impacts learning outcomes to improve teaching activities.

Therefore, this article will explore the multifaceted effects of multimedia integration on learning experiences within and beyond the classroom. The focus will be to explore issues such as the overview of multimedia in learning, the theoretical background of multimedia in learning, types of multimedia tools available, their suitability for different audiences, human senses and knowledge acquisition, avoiding cognitive overload and the evaluation methodologies that contribute to multimedia integration success, drawing on recent literature to highlight both its potential benefits and challenges, exploring possible solutions to increase learning outcomes in contemporary education.

Literature Review

Overview of Multimedia in Learning

Multimedia elements are various components such as text, graphics, sound, video, and animation that work together to create engaging and interactive content. Text provides information, graphics enhance visual appeal, sound enriches the experience, video combines moving images with audio, and animation adds motion to explain complex ideas. These elements collectively make content more dynamic and appealing (Nurjaya *et al.,* 2024).



Source:https://fastercapital.com/i/Multimedia-school-integration--Driving-Growth-Through-Multimedia--Insights-from-Successful-Business-Leaders--The-Multimedia-Revolution-in-Education.webp

The incorporation of multimedia tools in education has revolutionized traditional teaching methods, fostering an interactive and engaging learning environment. This approach bridges theoretical and practical knowledge, enhancing the overall educational experience. Digital content such as videos, podcasts, and simulations enrich traditional textbooks, while virtual reality offers immersive experiences (Naluwooza *et al.,* 2023). Multimedia stimulates multiple senses, enhancing retention and comprehension, with interactive e-books improving understanding by 23% compared to printed materials (Livingstone *et al.,* 2019). Collaborative platforms like educational wikis promote teamwork and critical thinking through co-created content (Ismoilovich & Ravshanbekovich, 2023). Adaptive learning software personalizes education by tailoring content to individual needs, enabling self-paced progress (Sonnenschein *et al.,* 2021). Additionally, global connectivity through the internet allows students to access diverse perspectives via webinars and online lectures (Alzubi, 2023). Overall, multimedia tools bridge theory and practice, fostering more effective and personalized learning experiences. Despite challenges like infrastructure and training, multimedia significantly enhances education by boosting engagement and learning outcomes, driving innovation, and preparing students for a digital future.

Learning as a Concept in Education

Learning is a dynamic and multifaceted process through which individuals acquire knowledge, skills, attitudes, and values. It involves active engagement, critical thinking, and problem-solving rather than passive information reception. Constructivist theories emphasize that learners build knowledge through interactions with their environment and peers (Nasir, 2024). Advances in technology, especially artificial intelligence, are increasingly personalizing learning experiences to meet diverse needs (World Economic Forum, 2024). Modern educational approaches highlight the importance of integrating technology, social interaction, and collaboration to enhance learning outcomes. Adapting teaching practices to these insights is essential for creating effective learning environments.

Theoretical Framework

The Cognitive Theory of Multimedia Learning (CTML) by Richard Mayer explains that effective learning happens when information is presented through both visual and

auditory channels. It is based on three key ideas: that humans process visual and auditory information separately, each channel has a limited capacity, and learners must actively engage with the material to learn effectively. CTML guides multimedia design to optimize learning by managing cognitive load and encouraging active processing (Mayer, 2021). Mayer's Cognitive Theory of Multimedia Learning emphasizes active learner engagement and outlines principles such as coherence, signaling, and redundancy to design effective multimedia instruction. Research validates that these principles enhance learner engagement and comprehension across educational contexts (Mayer, 2020, 2022; Yana, 2023; Edutopia, 2024). As technology evolves, ongoing studies continue to support multimedia's vital role in education.

Types of Multimedia Tools and Their Audience Suitability

Different multimedia tools suit various audiences based on demographics, preferences, and context. Videos engage broad and younger audiences, with short-form videos effective for quick messaging and longer videos for detailed learning (618Media, 2024). Podcasts appeal to multitasking listeners and niche groups through storytelling (DealFuel, 2024). Interactive content like quizzes fosters active participation, especially among younger users (618Media, 2024). Infographics provide clear, concise data visualization for professional audiences (DealFuel, 2024). Virtual Reality offers immersive experiences ideal for education and industries like real estate (618Media, 2024). Understanding these preferences helps tailor content effectively (618Media, 2024; DealFuel, 2024).

Multimedia Integration and Knowledge Concretization

Multimedia integration in education enhances the concretization of knowledge by transforming abstract concepts into tangible understanding through diverse and interactive representations (Piaget, 1976). It supports cognitive processing by reducing extraneous load via multiple formats, improving comprehension and retention (Sweller, 2019). Studies show that videos, simulations, and interactive elements aid practical application and deepen learning (Bouck *et al.*, 2020). Interactive multimedia fosters active and collaborative learning, helping students internalize and apply concepts effectively (Saini & Baba, 2023; Silva *et al.*, 2023). Additionally, multimedia promotes accessibility and inclusivity by incorporating features like captions and descriptive images, supporting learners with disabilities (InstinctHub, 2024). The evolution of technology has transformed teaching into dynamic, experiential learning environments, further enhancing engagement and understanding (Nature, 2023).

Multimedia Integration and Human Memory Strengthening and Retention

Instinctively, the integration of multimedia in education enhances memory retention and cognitive processing by combining verbal and visual information, as explained by Mayer's Cognitive Theory of Multimedia Learning (CTML) and Schnotz's Integrative Model of Text and Picture Comprehension (ITPC), which emphasize minimizing extraneous cognitive load. Multimedia use improves learning outcomes by increasing metamemory satisfaction and critical thinking (Saini & Baba, 2023), while active engagement with multimedia materials fosters integrated mental models for long-term retention (Chen & Liu, 2008). However, distractions such as smartphones negatively affect memory recall (Feng *et al.*, 2020). Additionally, multimedia serves as a motivational tool that enhances learner engagement and retention (ResearchGate, 2021). The evolving digital landscape mediates human memory processes, highlighting the importance of leveraging multimedia effectively in education (Williams, 2009; Nature, 2023).

The Role of Human Senses in Learning

Remarkably, human senses play a vital role in knowledge acquisition, as engaging multiple sensory modalities such as sight, hearing, touch, taste, and smell enhance

comprehension and memory retention by fostering richer cognitive associations (Maryville University, 2023). Multisensory learning environments that combine visual and auditory inputs improve student engagement and understanding, aligning with Mayer's Cognitive Theory of Multimedia Learning (Mayer, 2020; Nasir, 2024). Technological innovations like the feelSpace belt provide tactile feedback to augment sensory perception, significantly improving spatial knowledge acquisition (Schmidt *et al.*, 2023). Moreover, olfactory cues have been shown to trigger vivid memories, suggesting that incorporating smell in education can reinforce learning through emotional connections (Scientific American, 2020). These findings highlight the importance of multisensory approaches and sensory augmentation in enhancing educational outcomes.

Strategies for Avoiding Cognitive Overload

Cognitive Load Theory (CLT) complements Mayer's multimedia learning framework by explaining how working memory's limited capacity affects learning. CLT identifies three types of cognitive load: intrinsic (material complexity), extraneous (unnecessary effort from poor design), and germane (effort for meaningful processing) (Sweller, 2019; Paas & Kirschner, 2012). Effective multimedia design aims to reduce extraneous load and manage intrinsic load to optimize germane load, enhancing learning efficiency (Yana, 2023). Cognitive overload occurs when information exceeds working memory capacity, impairing retention (Sweller *et al.*, 2011). Strategies to prevent overload include chunking information, mixing modalities, creating low-stress environments, providing clear instructions with scaffolding, and using goal-free problem solving (Gottler, 2023; Evans *et al.*, 2024; Harris, 2022; Lehrblick, 2024). These approaches align with Mayer's theory that processing through separate auditory and visual channels requires active integration for effective learning. Integrating CLT with multimedia principles supports instructional designs that optimize cognitive load and improve educational outcomes. In addition, recent research underscores the importance of managing cognitive overload, especially in online learning environments where increased pace and structure can heighten cognitive demands (Gottler, 2023; Host, 2023). Assessing students' prior knowledge before introducing new content is crucial to align instruction with learner readiness and reduce overwhelm (Evans *et al.*, 2024). Effective strategies such as chunking information, mixing modalities, creating supportive environments, clear instructions, and goal-free problem solving enhance students' ability to process and retain information. Ongoing research into cognitive load remains essential for developing effective educational practices.

Benefits of Multimedia Integration

Multimedia solutions effectively enhance learner engagement, motivation, and comprehension by catering to diverse learning styles and providing dynamic, interactive content. Studies show that multimedia tools like videos, animations, and simulations increase student motivation and satisfaction, particularly by appealing to different learning preferences (Ziegler *et al.*, 2021; Naluwooza *et al.*, 2023; Samat & Aziz, 2020). These tools simplify complex concepts through multi-format presentations, improving retention and critical thinking skills (IJCRT, 2023 & Brajets *et al.*, 2023). Multimedia also promotes inclusivity by accommodating visual, auditory, and kinesthetic learners and enhancing accessibility for students with disabilities (Bingham & Conner, 2021; Gong, 2022; Ziegler *et al.*, 2021). Interactive features such as quizzes and virtual labs foster active learning and provide personalized feedback, supporting deeper understanding (Taufiqoh *et al.*, 2023; InstinctHub, 2024). Additionally, multimedia environments encourage collaboration and teamwork, further enriching learning experiences (Silva *et al.*, 2023). Overall, multimedia integration plays a vital role in modern education by improving engagement, comprehension, and inclusivity.

Limitations against Multimedia Integration in Learning

Nevertheless, multimedia integration in education faces significant challenges across technical, pedagogical, and institutional domains. Technical issues such as software malfunctions, hardware failures, and inadequate infrastructure disrupt learning and limit multimedia use, especially in resource-constrained settings (Rahman, 2018 & Al-Harbi, 2011). Pedagogically, many educators lack sufficient training and confidence to effectively use multimedia tools, leading to lower student engagement and difficulties in creating and updating quality content (Gudkova *et al.,* 2021 & IJFMR, 2023). Additionally, excessive multimedia use can distract students and impair critical thinking (Gao, 2011; Rahman, 2018). Institutionally, resistance to change and financial constraints hinder widespread adoption of multimedia technologies (Rahman, 2018). Addressing these limitations is crucial to harness the full potential of multimedia in educational settings (Sweller *et al.,* 2011; Ismoilovich & Ravshanbekovich, 2023).

Ensuring Best Practices for Effective Multimedia Integration

In essence, to address multimedia integration challenges in education, key solutions include ongoing professional development to enhance teacher competence (Alshammari, 2015), upgrading technological infrastructure to ensure reliable access (Gao, 2011), and adopting a balanced blended learning approach that supplements traditional methods with multimedia. Additionally, collaborative curriculum development ensures relevant and engaging multimedia content (Deutscher, 2009), while feedback mechanisms from students and teachers help refine multimedia use. Implementing these strategies is vital for maximizing the effectiveness of multimedia in learning environments. Intrinsically, to maximize the benefits of multimedia in learning, educators should consider the following best practices:

1. Align with Learning Objectives: Ensure that multimedia elements support specific educational goals.
2. Use Quality Media: High-quality content maintains student interest and enhances the learning experience.
3. Provide Clear Instructions: Offer guidance on how to navigate multimedia components effectively.
4. Incorporate Interaction: Utilize interactive elements to promote active learning.
5. Ensure Accessibility: Provide supplementary documentation for all multimedia materials to cater to diverse learners.
6. Continuous Monitoring: Regularly assess the effectiveness of multimedia integration and refine strategies as necessary.

Conclusion

The integration of multimedia in education significantly improves learning by making it more engaging, accessible, and effective. By thoughtfully using various media formats, educators can cater to diverse learning styles and enhance overall outcomes. However, to fully harness these advantages, it is important to overcome challenges related to implementation. As educational institutions continue to evolve with technological progress, addressing these issues will be key to maximizing the impact of multimedia in teaching and learning.

Acknowledgements

All cited literature, scholars, and various schools of thought are hereby acknowledged.

Declarations

No Conflict of Interest

References

618Media. (2024). *Multimedia campaigns: Future trends*. https://618media.com/en/blog/multimedia-campaigns-future-trends/

Al Natour, A., & Woo, H. (2021). Factors affecting teachers' use of multimedia in education: A review. *Education and Information Technologies, 26*(6), 7387–7406.

Al-Harbi, K. (2011). Challenges facing e-learning in Saudi Arabia: A case study. *International Journal of Computer Applications, 29*(4), 1–6.

Alzubi, M. (2023). The role of multimedia in enhancing learning outcomes. *Journal of Educational Technology, 15*(2), 45–60.

Bingham, S., & Conner, K. (2021). The role of internet technology in education: Enhancing engagement through multimedia. *International Journal of Education Technology, 15*(4), 123–134.

Bouck, E., et al. (2020). Interactive multimedia as a tool for enhancing learning outcomes: A review of the literature. *Journal of Educational Technology, 17*(1), 45–67.

Brajets, J., et al. (2023). The importance of multimedia means usage in improving the quality of education. https://www.brajets.com/index.php/brajets/article/download/1279/616

Chen, C.-H., & Wu, Y.-T. (2022). The effectiveness of multimedia learning environments on students' learning outcomes: A meta-analysis. *Educational Technology Research and Development, 70*(3), 567–586. https://doi.org/10.1007/s11423-021-10062-5

DealFuel. (2024). *25 best multimedia tools to transform your content creation*. https://www.dealfuel.com/blog/25-best-multimedia-tools-to-transform-your-content-creation/

Deutscher, S. (2009). Challenges faced by teachers using multimedia in science education.

Edutopia. (2024). *The 10 most significant education studies of 2024*. https://www.edutopia.org/article/the-10-most-significant-education-studies-of-2024

Evans, M., et al. (2024). Reducing cognitive overload for students in higher education. *Journal of Higher Education Theory and Practice, 24*(10), 200–210.

Gao, Y. (2011). The impact of multimedia on student engagement.

Gong, Y. (2022). The confluence of multimedia technology and children's drama education: Implications for preschool education. *Frontiers in Psychology, 13*. https://doi.org/10.3389/fpsyg.2022.907468

Gottler, A. (2023). Cognitive overload: How to prevent learner meltdown. https://amygottler.co.uk/instructional-design/cognitive-overload/

Gudkova, T., Kolesnikova, E., & Kolesnikov, A. (2021). The role of teachers' digital competencies in effective e-learning implementation. *Education Sciences, 11*(3), 123.

Harris, E. (2022). Using cognitive load theory to enhance best practice in teaching. Deans for Impact. https://consiliumeducation.com/itm/2022/03/23/avoiding-cognitive-overload/

Host, B. (2023). Understanding cognitive load! https://www.linkedin.com/pulse/understanding-cognitive-load-brian-host-ognwc

IJFMR. (2023). Scope and challenges of multimedia in the education sector. *International Journal of Finance & Management Research, 3*(2), 34–45.

InstinctHub. (2024). Exploring the importance of integrating multimedia in online teaching and learning. https://instincthub.com/blog/exploring-the-importance-of-integrating-multimedia-in-online-teaching-and-learning-part-1

Ismoilovich, A., & Ravshanbekovich, M. (2023). Multimedia technologies in education: Enhancing personalized learning. *International Journal of Educational Research, 12*(1), 22–35.

Lehrblick. (2024). Less is more: Four of the many ways to reduce cognitive load. https://lehrblick.de/en/less-is-more-four-of-the-many-ways-to-reduce-cognitive-load/

Livingstone, S., Carr, J., & Haddon, L. (2019). The impact of digital media on children's learning: A review of the literature. *Journal of Child Development, 90*(6), 1790–1805.

Maryville University. (2023). The importance of the 5 senses in learning and studying. https://online.maryville.edu/blog/importance-of-5-senses-in-learning/

Mayer, R. E. (2020). *Multimedia learning* (3rd ed.). Cambridge University Press.

Mayer, R. E. (2021). Interactive multimodal learning environments: A theoretical framework and implications for design and research. *Educational Psychologist, 56*(2), 107–121. https://doi.org/10.1080/00461520.2021.1891234

Moreno, R., & Mayer, R. E. (2021). Interactive multimodal learning environments: A theoretical framework and implications for design and research. *Educational Psychologist, 56*(2), 107–121. https://doi.org/10.1080/00461520.2021.1891234

Naluwooza, M., Muwanga-Zake, J., & Kizito, G. (2023). Enhancing learning experiences through multimedia in education: A systematic review. *Journal of Educational Research, 116*(1), 12–25.

Nasir, N. S. (2024). A vision for the future of learning. *Educational Researcher, 53*(1), 1–10. https://doi.org/10.3102/0013189X231222223

Nature. (2023). The impact of digital tools on contemporary educational practices: A comprehensive overview. *Nature Reviews Education, 1*(1), 15–30.

Nurjaya, Y., Maulana, I. S., Maulida, I. S., Bakri, & Laratmase, A. J. (2024). The impact of multimedia elements on tablets and digital stories in learning process management. *Journal of Education Technology, 8*(1), 136–146. https://doi.org/10.23887/jet.v8i1.71326

Paas, F., & Kirschner, P. A. (2012). Cognitive load theory: A broader view on the role of working memory in learning and instruction. *Educational Psychology Review, 24*(3), 301–314. https://doi.org/10.1007/s10648-012-9190-5

Piaget, J. (1976). *The child and reality: Problems of genetic psychology*. Viking Press.

Rahman, M. (2018). Barriers to successful integration of ICT in teaching.

Saini, G., & Baba, M. M. (2023). Psychological expedient of multimedia in blended learning and metamemory satisfaction. *The Learning Organization, 30*(5), 1–15. https://doi.org/10.1108/TLO-06-2022-0112

Schmidt, J., et al. (2023). Improved spatial knowledge acquisition through sensory augmentation: A study using the feelSpace belt. *Brain Sciences, 13*(5), 720. https://doi.org/10.3390/brainsci13050720

Scientific American. (2020). The science behind smell-driven memories. https://www.scientificamerican.com/article/the-science-behind-smell-driven-memories/

Silva, R., et al. (2023). Enhancing collaborative learning through interactive multimedia environments. *International Journal of Instruction, 16*(2), 101–118. https://doi.org/10.29333/iji.2023.1627a

Sonnenschein, S., Tschirner, J., & Schmidt, H. (2021). Bridging home and school learning through multimedia. *Educational Review, 73*(5), 678–694. https://doi.org/10.1080/00131911.2020.1720982

Sweller, J. (2019). Cognitive load theory: A broader view on the role of working memory in learning and instruction. *Educational Psychology Review, 31*(2), 245–267. https://doi.org/10.1007/s10648-019-09465-5

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive load theory*. Springer Science & Business Media.

Tafazoli, D. (2022). The effect of mobile-based interactive multimedia on thinking engagement among EFL students at higher education level. *International Journal of Instruction, 15*(1), 45–60. https://doi.org/10.29333/iji.2022.1513a

Taufiqoh, Z., et al. (2023). The effectiveness of multimedia-based learning to accelerate learning after the pandemic at the basic education level. *International Journal of Education, 12*(2), 45–60.

World Economic Forum. (2024). The future of learning: AI is revolutionizing education 4.0. https://www.weforum.org/stories/2024/04

Yana, W. K. (2023). Multimedia learning theory: Implications for instructional design and practice. In *Theoretical Models for Teaching and Research*. https://opentext.wsu.edu/theoreticalmodelsforteachingandresearch/chapter/multimedia-learning-theory/

Ziegler, A., et al. (2021a). Effects of multimedia integrated fine arts education on students' learning attitudes: A quasi-experimental study. *Educational Studies, 47*(3), 335–354. https://doi.org/10.1080/03055698.2021.1914391

IMPACT OF COLLABORATIVE APPS ON THE PERFORMANCE OF BLIND STUDENTS IN SPECIAL NEEDS SCHOOLS IN ILORIN METROPOLIS

[1]Soetan. A. K., [2]Adewoye. F. T., [3]Usman M., and [4]Oyebanji. B. R.
Department of Educational Technology
University of Ilorin, Kwara State
Corresponding Author Email Address: monsuratoyin500@gmail.com, gsm: 08107282348

Abstract

Collaborative application are hardware and software devices that can help people with disabilities and special needs to overcome the challenges of learning and information. However, special education in Nigeria is currently faced with a lot of problems ranging from low funding, unavailability of collaborative application and ignorance in operation of assistive technological gadgets.. Hence, this study investigated the impact of collaborative apps on the performance of blind students in special needs schools in Ilorin metropolis. This study (i) investigated the impact of collaborative apps utilisation on the performance of blind students and; (ii) examined the impact of collaborative applications utilisation on the performance of blind students based on gender.

Purposive Sampling technique was used to select eighty-two (82) special education students that were randomly selected from four (4) special education schools in Ilorin metropolis, using a simple random sampling technique. Frequency counts, percentage, mean and standard deviation were used to answer research the question while indefinite t-test was used to test the hypothesis at 0.05 level of significance.

The findings of the study were that:

1. students perceived collaborative applications positively, with a grand mean of 3.65, indicating improvement on access, communication, and engagement.
2. the t-test results indicated no significant difference based on gender on collaborative applications on students' performance, with a p-value =0.060. t-value =1. 906.Then male and female students show similar levels of impact

The study concluded that use of computers and apps in schools for the Blind, enhanced the skills acquisition, mastery of instructional content and improve academic performance of students with visual impairment. The study recommended among others that Educators should be trained not only on the technical use of these apps but also on pedagogical strategies that leverage the collaborative features to foster intrinsic motivation.

Keywords: Academic performance, Assistive technology, Blind students, Collaborative applications, Special education, Visual impairment.

Introduction

Education is a continuous learning process that involves the use of information in changing the behaviour of a learners. The branch of education that deals with learners with disabilities is referred to as special education. These limitations can range from visual, physical, mental, emotional or hearing impairments or a combination of two or more of these impairments. Special education was defined as "a customized educational programme, designed to meet the unique needs of persons with special needs that the general educational programme cannot cater for" (National Policy on Education, 2016). It was further stated that special education deals with the education of the disabled who may have visual impairment, hearing impairment, physical and health impairment, mental retardation, emotionally disturbed,

speech impairment, learning disabled or multiple impairments (Yusuf, Fakomogbon & Issa 2019).

The main purpose of teaching and learning at any level is to bring out a significant change in the learner. However, transferring knowledge requires teachers to use the appropriate method and pedagogy that best suits learners' objectives and desired outcomes. Thus, effective teaching methods is required to stimulate learners' interest in order to form a base for achieving desired curriculum objectives in a school setting (Maheshwari, 2017). Technology makes things easier and possible for people with disabilities (Radabaugh, 2018). Assistive technology (AT), is of high importance for learning in specials schools, and cannot be overestimated in terms of its educational benefits to learners with disabilities as it has proved to be of help in increasing, maintaining or learners' functional capabilities.

Modern technologies can change the lives of students with disabilities, enabling them to access the curriculum, participate in learning activities alongside peers to achieve their full potential. The employment of assistive technologies (AT) and accessing them will help school personnel make informed decisions when to evaluate students with special needs. This knowledge will help schools develop educational environments and programs that can meet the needs of all students, regardless of whether they have disabilities (Massachusetts Department of Elementary and Secondary Education, 2019).

Collaborative application can be applied as adaptive technologies for persons with visual impairments through the use of screen readers, Braille and Braille embossers, desktop video magnifiers, screen magnification software, large-print and tactile keyboards, navigation assistance, and so on; (Barrue, 2018). The availability, application and use of collaborative application in special needs schools have raised questions among researchers over the years. The principal reason for providing assistive technology in school is to enable students to meet the instructional goals set forth for them. School personnel should look at tasks that each student needs to accomplish, the difficulties the student is having, and the ways that various devices might help the student better accomplish those tasks (Massachusetts Department of Elementary and Secondary Education, 2020). Collaborative application can exist as hardware and software devices that can help people with disabilities and special needs to overcome the challenges of learning and information that they might be facing. Although, there are a few available assistive technologies today, some people, due to gender and other reasons, are finding it difficult to integrate.

Children with sight disabilities face extreme disparities and daunting challenges to the enjoyment of academic, social, and community participation in low and middle-income countries (World Health Organization, WHO, 2019). They are subjected to additional discrimination and social exclusion based on age, gender, social status, language, ethnicity, religion, living in conflict zones and other factors. Girls with disabilities are particularly at risk of discrimination and abuse (WHO & UNICEF, 2019). Gender differences concerning the use of technology and the attitude towards technology is another broad research field. Whereas gender is widely researched in the context of information technologies, it has not been subject studies on acceptance of medical (assistive) technologies (Wilkowska, Gaul & Ziefle, 2020). Several studies revealed that men have a greater interest and a more positive attitude regarding computer usage, due to a higher self-esteem and greater experience with information technologies (Schumacher & Morahan-Martin, 2017; Meelissen & Drent, 2018). In the context of technology adoption in workplace studies showed that there are different aspects that influence the decision to adopt new computer technologies of men and women. For men, it is mainly their attitude towards using a new technology whereas women are more influenced by subjective norm and behavioural control (Morris, Venkatesh & Ackerman, 2015).

Special education teachers, especially in middle and high school, should be exposed to technological tools that can help students to bypass their academic weaknesses Schumacher & Morahan-Martin, (2021). Teachers will help students by training them to use portable and cheap tools that, in most cases, could make students live and behave more independently when they leave high school, which will increase their chances of maximizing their degree of achievement and independence, though it will still be behind their peers without disabilities (Blackorby & Wagner, 2016; Alnahdi, 2018).

Most studies that examined the availability of collaborative application for special education were conducted outside Nigeria; in fact, very few have examined the application of ICT for students with disability within the African context (Farrell & Shafika, 2017; Yusuf, Fakomogbon & Issa, 2019). Hence, this study may provide helpful tips on the prospect of technology, integration, approval, usage for teaching and learning in Nigeria as it will investigate impact of collaborative apps on the performance of blind students in special needs schools in Ilorin metropolis.

Statement of the Problem

Teachers teach children who have different intellectual, physical, sensory, or emotional abilities (Heard, 2019). Learners with disabilities face many challenges towards attending school and partaking in formal education. Without assistive technology (AT) and accessible environments, children with disabilities may be unable to attend school, see what is written on the blackboard, hear and understand the teacher, read the textbooks, use sanitation facilities, participate in sports and recreation, and interact with classmates (WHO & UNICEF, 2015). Special education in Nigeria is currently faced with a lot of problems ranging from low funding of special schools, unavailability of collaborative application in special schools and ignorance in operation of assistive technological gadgets. Hence, this study found out if collaborative applications are available and are being utilised properly.

Purpose of the Study

This study investigated the impact of collaborative apps on the performance of blind students in special needs schools in Ilorin metropolis. Specifically, this study;

1. examined the impact of collaborative apps utilisation on the performance of blind students in Ilorin metropolis
2. determined the impact of collaborative applications utilisation on the performance of blind students based on gender.

Research Questions

This study provided answers to the following research questions:

1. What are the impact of collaborative apps utilisation on the performance of blind students in Ilorin metropolis?
2. What are the impact of collaborative apps on the performance of blind students based on gender?

Research Hypothesis

H_{01}: There is no significant difference in the impact of collaborative applications utilization on students' performance based on gender.

Literature Review

Concept of Collaborative applications

Collaborative applications include a range of technologies which enable people to build upon their abilities and participate as fully as possible at home, school and in their community (USAID, 2019) Collaborative technology is a range of strategies and resources

which includes services and tools, used to enable a student to meet learning outcomes or to improve or maintain a student's ability to meet learning outcomes. The use of this technology should not be viewed as an activity, but rather as a means of achieving goals (Scoring, 2016). International Classification of Functioning, Disability and Health (ICF, 2019) defines collaborative applications and technology as "any product, instrument, equipment or technology adapted or specially designed for improving the functioning of a person with a disability."

Drawing from the ICF, the International Organization for Standardization (ISO 2018) defines collaborative products more broadly as "any product, especially produced or generally available, that is used by or for persons with disability: for participation; to protect, support, train, measure or substitute for body functions/structures and activities; or to prevent impairments, activity limitations or participation restrictions. This includes devices, equipment, instruments and software." IDEA (Individuals with Disabilities Education Act, 2019) and the Regulations Governing Special Education Programs for Children with Disabilities in Virginia defined an AT device as "any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of a child with a disability."

Collaborative applications are important for students with disabilities, but there are those who say the system should be supported for all students, and this system or framework is referred to as Universal Design for Learning (UDL) (whender, 2016). The challenge that students with disabilities face in the context of inclusive education is the single-faceted presentation of the general education curriculum, which leads us again to think of Universal Design for Learning (UDL) as a solution to meet this challenge (Fosha, 2017).

Methodology

Research Design

This study employed descriptive research design of the survey type which aimed at investigated the impact of collaborative apps on the performance of blind students in special needs schools in Ilorin metropolis

Sample and Sampling Techniques

Purposive sampling technique was used in selecting the sample for this research study. The population for this study comprised of special education students in Ilorin metropolis. The target population for the study comprised of eighty-two (82) special education students that was randomly selected from four (4) special education schools in Ilorin metropolis. Using a simple random sampling technique.

Result

Table 1: Distribution of respondents by Gender

Gender	Frequency	Percentage (%)
Male	38	46.3
Female	44	53.7
Total	82	100.0

Table 1 presented the distribution of respondents by gender, showing that out of a total of 82 participants, 38 were male (46.3%) and 44 were female (53.7%). This distribution indicated a slightly higher representation of female respondents compared to male respondents, with females comprising just over half of the sample. The relatively balanced gender distribution, with a slight skew towards female participants, suggests that the study has

input from both male and female perspectives, though with a slight emphasis on female views. This balance is important for ensuring that the findings are not heavily biased towards one gender, allowing for a more comprehensive understanding of the variables being studied.

Research Question 1: What are the impact of collaborative apps utilisation on the performance of blind students in Ilorin metropolis?

Table 2: Impact of collaborative apps utilisation on the performance of blind students in Ilorin metropolis

S/No	Items	Mean
1.	Collaborative apps have improved my ability to access and interact with educational materials.	3.59
2.	Using collaborative apps has enhanced my communication and collaboration with peers and instructors.	3.50
3.	Collaborative apps have increased my engagement in class discussions and group activities.	3.85
4.	Collaborative apps have improved my overall academic performance.	3.97
5.	Collaborative apps have improved my ability to participate in group projects and assignments.	3.67
6.	Collaborative apps have increased my independence in accessing and managing educational resources.	3.86
7.	I feel more motivated to study and learn when using collaborative apps.	2.92
8.	Collaborative apps have effectively supported my learning needs as a blind student.	4.00
9.	Blind students may face technical challenges when using collaborative apps, such as compatibility issues with screen readers or other assistive technologies.	3.50
10.	Internet restricts my access to collaborative applications.	3.69
	Grand mean 3.65	

Bench mark 2.5

The table presented impact of collaborative apps utilisation on the performance of blind students in Ilorin metropolis. The mean scores for all items were above the benchmark of 2.5, with a grand mean of 3.65, indicating a generally positive view of these tools. Students felt that collaborative apps have significantly improved their ability to access and interact with instructional materials with mean score of 3.59, enhanced their communication and collaboration with peers and instructors with mean score of 3.50, and increased their engagement in class discussions and group activities with mean score of 3.85. The highest-rated item is the effectiveness of these apps in supporting the learning needs of blind students with mean score of 4.00, suggesting that these tools are particularly beneficial in addressing the specific challenges faced by this group.

Despite the overall positive feedback, some concerns remain, particularly regarding motivation and technical challenges. The item "I feel more motivated to study and learn when using collaborative apps" has the lowest mean score of 2.92, indicating that while the apps are effective, they may not significantly boost students' motivation. Additionally, students acknowledge potential technical challenges, especially compatibility issues with screen readers or other assistive technologies with mean score of 3.50, and the internet's role in restricting access to these applications with mean score of 3.69. These findings suggest that while collaborative apps are largely beneficial, there are areas that need further attention to optimize their effectiveness and accessibility.

Research Hypothesis

H_{01}: There is no significant difference in the impact of collaborative applications utilization on students' performance based on gender.

Table 3: t-test showing significant difference in the impact of collaborative applications utilization on students' performance based on gender

Gender	N	Mean	SD	Df	T	Sig.2 (tailed)	Remark
Male	38	37.31	1.75				Not rejected
				80	1.906	0.060	
Female	44	35.95	4.08				
Total	82						

Table 6 presented the results of a t-test analysis that examines whether there is a significant difference in the impact of collaborative applications on students' performance based on gender. The mean score for male students is 37.31 with a standard deviation of 1.75, while the mean score for female students is slightly lower at 35.95 with a standard deviation of 4.08. Although the mean performance of males is slightly higher, the t-test value of 1.906 and the p-value of 0.060 indicate that this difference is not statistically significant at the conventional alpha level of 0.05.The result "Not rejected" under the remarks column indicates that the null hypothesis, which states there is no significant difference in the impact of collaborative application utilization on students' performance based on gender, cannot be rejected. This suggests that both male and female students benefit similarly from the use of collaborative applications in their education, with no significant gender-based disparities in their performance outcomes.

Summary of Findings

1. Collaborative applications have positive impact on students, with a grand mean of 3.65, indicating they improve access, communication, and engagement. However, challenges like motivation and technical issues still persist, suggesting areas for further enhancement.
2. The t-test results indicated no significant gender-based difference in the impact of collaborative applications on students' performance, with a p-value of 0.060. Both male and female students show similar levels of impact from using these applications.

Discussions

The results from Table 2 and Table 3 provide a comprehensive view of the impact of collaborative applications on the educational experiences of blind students in Ilorin metropolis. The grand mean of 3.65, which is well above the benchmark of 2.5, strongly indicates that collaborative applications positively impact students in their learning process. This positive perception is particularly evident in areas such as enhanced accessibility, improved communication, and increased engagement. The exceptionally high mean score for the item, "Collaborative apps have effectively supported my learning needs as a blind student" with mean score of 4.00, is a critical finding. It underscores the potential of these technologies to serve as powerful assistive tools that directly address the unique learning barriers faced by visually impaired students, empowering them to interact with educational content and peers more effectively. This confirms that, when implemented appropriately, collaborative apps can be a significant enabler of inclusive education.

Despite the overwhelmingly positive feedback, the data also revealed important areas for improvement. The lowest mean score for motivation with mean score of 2.92 suggests that while the apps are effective instructional tools, they may not be a primary driver of intrinsic motivation for studying. This implies that while these tools facilitate learning, educators may need to integrate additional motivational strategies. Furthermore, the students' acknowledgment of technical challenges with mean score of 3.50 and internet access limitations with mean score of 3.69 highlights practical barriers to seamless integration. These issues specifically, compatibility with screen readers and inconsistent internet connectivity are crucial and must be addressed to ensure equitable and sustained access for all students. This nuance in the data is vital as it provides actionable insights for developers and educational institutions to refine the technology and infrastructure to better serve this demographic.

Regarding the research hypothesis, the t-test results in Table 3 showed that gender did not have a significant impact on students' performance when using collaborative applications. With a p-value of 0.060, which is greater than the conventional significance level of 0.05, the null hypothesis is not rejected. This finding is significant because it suggests that the benefits of using these apps are equitable across genders. The collaborative nature of the applications ensuring that both male and female blind students can leverage the technology to achieve similar performance outcomes. This result is particularly valuable for promoting gender equality in technology-enhanced learning, indicating that implementation strategies and pedagogical approaches do not need to be tailored differently for male and female students in this context.

Conclusion

The study concluded that the utilisation of collaborative applications had a positive impact on the learning experiences and performance of blind students in Ilorin metropolis. The findings revealed that the application of computers and apps in School for the Blind, enhanced the skills acquisition, mastery of instructional content and improved academic performance of students with visual impairment. Crucially, the study also concluded that the benefits of these applications are equitable across genders, as the t-test results showed no significant difference in performance based on gender.

Based on the conclusions of the study, it is therefore recommended among others that educators should be trained not only on the technical use of these apps but also on pedagogical strategies that leverage the collaborative features to foster intrinsic motivation.

References

Barrue, C. (201[7]). *Personalization and Shared Autonomy in Assistive Technologies.* Ph.D Thesis. Universitat Politechnica de Catalunya.

Christopher, M. (2016) Education of the Disabled in Nigeria: Access and Perception. *Journal Plus Education, 10*(1), 133-142.

Farrell, G. and Shafika, I. (2017). *Survey of ICT and education in Africa: A summary report based on 53 country surveys.* Washington, DC: World Bank. Retrieved from http://www.infodev.org/en/Publication.353.html.

Hardman, M. (2019). Redesigning the preparation of all teachers within the framework of an integrated program model. *Teaching and Teacher Education, 25*(4), 583-587.

Blackorby, J., & Wagner, M. (2016). Longitudinal postschool outcomes of youth with disabilities: Findings from the National Longitudinal Transition Study. *Exceptional Children, 39*, 399-413.

Massachusetts Department of Elementary and Secondary Education. (2015). *Access to Learning: Assistive Technology and Accessible Instructional Materials.* Massachusetts : MDESE.

Morris, M., Venkatesh, V. & Ackerman, P. (2015). Gender and age differences in employee decisions about new technology: an extension to the theory of planned behavior. In *IEEE Transactions on Engineering Management* (pp. 52(1), 69–84).

Radabaugh, M. (2016). *Assistive Technology: Independent Living Centre NSW.* Retrieved from: http://www.ilcnsw.asn.au/home/assistive_technology/assistive_technology

Schumacher, P. & Morahan-Martin, J. (2021). Gender, internet and computer attitudes and experiences. In *Computers in Human Behavior* (pp. 17, 95–110).

WHO & UNICEF. (2022). *Early childhood development and disability: A discussion paper.* Geneva: World Health Organization.

UNDERGRADUATES' ATTITUDE TOWARDS THE USE OF ARTIFICIAL INTELLIGENCE IN LEARNING IN UNIVERSITY IN ILORIN, NIGERIA.

[1]Soetan. A. K., [2]Usman M and [4]Oyebanji B. R.
Department of Educational Technology
University of Ilorin, Kwara State
Corresponding Author Email Address: monsuratoyin500@gmail.com, gsm: 08107282348

Abstract

Artificial intelligence (AI) is an advancement of data innovation-based personal computer (PC) frameworks or other machines to do tasks that normally need human understanding and rational thought. However, poor performance among student in Nigerian universities on the use of artificial intelligence for learning is high (Awesu, 2018). Hence the study examined the undergraduates' attitude towards the use of Artificial intelligence for learning in University of Ilorin, Ilorin, Kwara State, Nigeria. This study examined; (i) the attitude of Undergraduates towards the use of artificial intelligence in learning (iv) determined undergraduates' attitude towards the use of artificial intelligence for learning base on gender.

The research was a descriptive design of the survey type. The sample for the study consisted of 218 undergraduates sampled from different department in the titled University, Kwara State. Mean and standard deviation was used to answer the research question while the hypothesis was tested using independent t-test.

The findings of the study showed that:

Undergraduate have a positive attitude towards the use of Artificial Intelligence.

There is no significant difference in use of artificial intelligence among undergraduate based on gender. ($t(218) = -2.17$, $p<0.5$)

The study concluded among others that undergraduates have positive attitude towards the use of Artificial Intelligence for teaching. It is therefore recommended that institutions should ensure equitable access, provide relevant training, and implement inclusive strategies on diverse needs and preferences of all learners.

Keywords: Artificial Intelligence, Attitude, Educational Technology, Gender, Inclusive Learning, Learning.

Introduction

Education is the process through which individuals acquire knowledge, skills, and values via teaching, training, and instruction. It is a structured and intentional journey aimed at developing cognitive, emotional, and social abilities, empowering individuals to contribute to society, realize their full potential, and thrive in their chosen fields (Davis, 2019). Information and Communication Technology (ICT) refers to the use of digital tools for retrieving and processing information. ICT plays a significant role in enhancing teaching and learning, with tools like classroom apps, mobile applications, and AI improving the learning experience. Artificial Intelligence (AI) involves the use of advanced computer systems or machines to perform tasks that usually require human intellect and reasoning (Jain & Jain, 2019). AI is being increasingly integrated into various industries, with higher education being a prominent sector where it has shown considerable impact. According to a McKinsey (2018) report, AI can enhance educational efficiency, which is essential for boosting productivity. With the rise of the Fourth Industrial Revolution, driven by AI (Xing & Marwala, 2018), which is now fulfilling its potential by leveraging data, processing capabilities, and algorithms (Mhlanga, 2021), understanding AI's role in education becomes crucial.

Artificial Intelligence (AI) improves education by fostering skill development and increasing global engagement, enhancing higher education curricula, supporting personalized learning, assisting in the creation of e-learning platforms, and streamlining data management. These advancements reduce administrative burdens and accelerate decision-making (Slimi, 2021). Additionally, AI's influence on evaluation methods and its connection to future employment opportunities underline the need for higher education institutions to incorporate AI to better prepare graduates for the workforce. However, challenges persist in the educational sector, such as inadequate services, poor quality of instruction, a lack of qualified teachers, and underperformance among students (Onasanya, 2018).

In Nigerian universities, student underperformance in using AI for learning is a growing concern (Awesu, 2018). Motivating students to utilize AI as an instructional tool is vital, as using technologies like machine learning and computer vision to explore complex concepts can make learning more tangible and meaningful. As the education system evolves to meet 21st-century demands, this study aims to examine the extent to which AI is integrated into students' learning processes, identify the challenges they face in effectively using AI technologies, and assess the impact on their educational outcomes. The research will also explore the level of AI literacy and competency among undergraduates, as well as the motivational factors that either encourage or hinder their use of AI in learning.

Research Question

1. What is the attitude of Undergraduates towards the use of artificial intelligence in learning?
2. What is the attitude of undergraduate towards the use of artificial intelligence for learning base on gender?

Research Hypothesis

H01: There is no significant difference in Undergraduates attitudes towards the use of Artificial intelligence for learning based on gender.

Literature Review

Artificial Intelligence in Education

The integration of Artificial Intelligence (AI) in education represents a groundbreaking shift in teaching and learning paradigms. AI's nature in education encompasses its foundational technologies and applications, including machine learning, natural language processing, and data analytics, to create systems that can enhance the educational experience. Artificial Intelligence, at its core, involves the creation of algorithms and systems capable of performing tasks that typically require human intelligence. These tasks include but are not limited to, natural language processing (NLP), machine learning (ML), computer vision, and robotics. The nature of AI is characterized by its adaptability, learning capacity, and ability to process and analyze large datasets. Russell and Norvig (2016) provide a foundational understanding of AI, highlighting its potential to solve complex problems through intelligent automation and decision-making processes.

Artificial Intelligence is the development of systems that would necessitate advanced human intelligence to perform tasks requiring a high degree of "inference, deduction, and perception" (Aldosari, 2020). It refers to intelligence displayed by machines rather than people. A significant difference between humans or animals and AI is that human or animal intelligence encompasses awareness and emotions, whereas AI lacks these characteristics (August *et al.,* 2021). Luckin (2017) added that AI is the capacity of computer systems to act in ways that we would consider human. August and Tsaima (2021) defined AI as the study of how to make

computers accomplish activities that appear to need intelligence when performed by people. This broad concept of artificial intelligence includes machine learning and deep learning.

Machine learning is a subset of AI, and it entails the use of algorithms that can recognize patterns in data, learn from those patterns, improve over time, and draw conclusions when presented with new information (Ramlakhan *et al.*, 2022). So basically, machine learning is a technique that allows computers to learn from data via the use of algorithms. According to Mitchell (1997), depending on the type of learning task, machine learning algorithms can be supervised, unsupervised, or reinforcement-based. Training a model on a labeled dataset, where the desired result is known for each input, is referred to as supervised learning. While reinforcement learning includes learning via trial and error while getting input from the environment, unsupervised learning involves identifying patterns and structures in unlabeled data. Deep learning is a subset of machine learning. Deep learning is a type of machine learning that uses artificial neural networks to learn (Janiesch *et al.*, 2021). According to LeCun et al. (2015), deep learning has demonstrated to be particularly successful in tasks that demand hierarchical models for the data as well as those that require processing vast volumes of unstructured input, such as pictures, audio, and natural language.

METHODOLOGY

Research Design

The study employed a descriptive research design of the survey type to investigate motivation and readiness of Undergraduates towards the use of artificial intelligence for learning at the University of Ilorin.

Sample and Sampling Techniques

A random sampling technique was employed to select 218 participants that responded to the questionnaire. This technique ensured that each student has an equal chance of being chosen to participate in the survey. Two hundred and eighteen (218) students were selected to respond to the designed questionnaires for this research.

Result

Table 1: Percentage Distribution of Respondents by Gender

Gender	Frequency	Percentage (%)
Male	124	56.9
Female	94	43.1
Total	218	100.0

Research Question 1: What is the attitude of Undergraduates towards the use of artificial intelligence in learning?

Table 2: Attitude of Undergraduate towards the use of artificial intelligence for learning

S/N	Items	Mean	Remark
A.	I interact with other students using Artificial intelligence	3.08	Agreed
B.	I feel comfortable having AI on my mobile app	3.42	Agreed
C.	Lessons on Artificial Intelligence are interactive	3.34	Agreed
D.	I feel free to express my opinion on AI	3.38	Agreed
E.	I feel excited when using Artificial intelligence to learn	3.33	Agreed
	Grand-mean	**3.31**	

Table 2 showed Attitude of Undergraduate towards the use of artificial intelligence for learning. The result revealed that interact with other students using Artificial intelligence with the mean score 3.08, students feel comfortable having AI on my mobile app with mean score 3.42. admitted that Lessons on Artificial Intelligence are interactive with mean score 3.34, feel free to express their opinion on AI with mean score 3.38 and feel excited when using Artificial intelligence to learn with mean score 3.33. The grand mean of 3.31 is higher than the benchmark means of 2.50, which was adopted as the cut-off mean score for making a decision on. Therefore, it is concluded that undergraduates have positive attitude towards the use of artificial intelligence for learning.

Research Hypothesis

H01: There is no significant difference in Undergraduates attitudes towards the use of Artificial intelligence for learning based on gender.

Table 3: Independent sample t-test on Attitude of Undergraduate towards the use of Artificial intelligence for learning based on gender.

Gender	N	X	SD	Df	T	Sig.2 (tailed)	Remark
Male	124	16.21	2.64	215	-2.47	0.14	Rejected
Female	93	17.04	2.12				
Total	218						

Table 6 showed that the calculated t-value (-2.47) on 215 degrees of freedom, P-value (sig.2-tailed) 0.14 was lesser than 0.05 level. Therefore, the null hypothesis which states that there is no significant difference in the attitude of undergraduate towards the use of artificial intelligence for learning based on gender was rejected. This implies that there is a significant difference in the attitude of undergraduates towards the use of artificial intelligence for learning based on gender in favor of female.

Summary of Findings

1. Undergraduates have positive attitude towards the use of artificial intelligence for learning
2. There is a significant difference in the attitude of undergraduate towards the use of artificial intelligence for learning based on gender.

Discussions

The findings of this study revealed that undergraduates have a positive attitude towards the use of artificial intelligence (AI) for learning. This aligns with the reviewed literature that portrays AI as a transformative force in modern education, Russell and Norvig (2016) emphasized that AI technologies such as machine learning and natural language processing have the capacity to simulate intelligent behavior, thereby enhancing learning experiences through personalized recommendations, adaptive learning paths, and intelligent tutoring systems. This supports the students' perception that AI makes learning more interactive and engaging. Luckin (2017) further suggests that AI can perform human-like educational tasks, providing students with on-demand feedback, automating repetitive processes, and creating learning environments that respond to individual needs. The students' positive response such as feeling excited and comfortable with AI echoes Aldosari's (2020) assertion that AI fosters high level of inference and deduction, enabling learners to explore content more deeply and independently.

The research hypothesis observed significant gender difference in attitudes toward AI in favor of female students adds a compelling dimension to the discourse. While earlier works often presumed males to be more inclined toward technology (August *et al.,* 2021), newer studies acknowledge that when AI systems are made more intuitive and learner-centered, female students increasingly embrace them. This could be linked to AI's adaptability and responsiveness, characteristics highlighted by Janiesch et al. (2021), which make digital learning more approachable across diverse user groups. Moreover, Ramlakhan et al. (2022) noted that machine learning techniques in educational apps can reduce cognitive overload and help students regardless of background focus on meaningful learning. This possibly explains the higher affinity female students show toward AI when it is embedded in user-friendly mobile apps. Thus, these findings suggest that both the design of AI systems and their integration into academic settings should account for diverse learner profiles to maximize engagement and educational outcomes.

Conclusion

The study concluded that undergraduates have positive attitude towards the use of artificial intelligence (AI) in learning, indicating their readiness to embrace emerging technologies in education. This positive disposition reflects AI's potential to enhance interactivity, personalization, and engagement in academic tasks. The study also revealed a significant gender-based difference in attitudes, with female students demonstrating a slightly more favorable view of AI integration. As AI continues to shape educational experiences, it is therefore recommended that institutions should ensure equitable access, provide relevant training, and implement inclusive strategies for the diverse needs and preferences of all learners.

References

Alexander, D. (2018). *Artificial intelligence: A new challenge of law*. *International Forum*, **21**(1), 45–52.

Aldosari, B. (2020). Artificial intelligence and the future of learning. *International Journal of Educational Technology*, **6**(2), 140–150.

August, O., & Tsaima, A. (2021). Artificial intelligence and education in Africa: Opportunities and challenges. *Journal of Digital Education*, **9**(3), 101–112.

Awesu, A. (2018). Challenges and prospects of integrating artificial intelligence into Nigerian tertiary education. *African Journal of Educational Technology*, **13**(2), 88–94.

Davis, P. (2019). *The purpose and power of education*. New York: Learning Path Publishers.

Jain, R., & Jain, S. (2019). The emergence of artificial intelligence in higher education. *Journal of Computer and Educational Research*, **12**(4), 56–63.

Janiesch, C., Zschech, P., & Heinrich, K. (2021). Machine learning and deep learning. *Business & Information Systems Engineering*, **63**(4), 329–340. https://doi.org/10.1007/s12599-021-00644-w

Jeofrey, M. (2019). The role of ICT in modern education. *International Journal of Education and Development*, **5**(1), 65–74.

LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. *Nature*, **521**, 436–444. https://doi.org/10.1038/nature14539

Luckin, R. (2017). *Towards artificial intelligence-based assessment systems*. Pearson.

McKinsey & Company. (2018). *Notes from the AI frontier: Insights from hundreds of use cases*. Retrieved from https://www.mckinsey.com/

Mhlanga, D. (2021). Artificial intelligence in higher education: A panacea for improved

quality. *Education and Information Technologies*, **26**, 4745–4767. https://doi.org/10.1007/s10639-021-10461-2

Mitchell, T. M. (1997). *Machine learning*. New York: McGraw-Hill.

Onasanya, S. A. (2018). Challenges facing education in Nigeria: A technology perspective. *Nigerian Journal of Educational Technology*, **18**(1), 1–9.

Ramlakhan, N., Singh, A., & Pillay, K. (2022). Integrating machine learning in educational systems. *International Journal of Artificial Intelligence in Education*, **32**(2), 125–141. https://doi.org/10.1007/s40593-021-00251-9

Russell, S., & Norvig, P. (2016). *Artificial intelligence: A modern approach* (3rd ed.). Pearson Education.

Slimi, Z. (2021). Artificial intelligence in education: Promises and implications. *Education and Information Technologies*, **26**, 2711–2728. https://doi.org/10.1007/s10639-020-10330-1

Xing, B., & Marwala, T. (2018). *The Fourth Industrial Revolution: AI and education in South Africa*. SpringerBriefs in Computer Science.

ETHICAL CHALLENGES OF INTEGRATING AI INTO TECHNOLOGY EDUCATION ASSESSMENT

NUFFI, O.Jonathan PhD
Tel: +2348066651112
Email: nuffijonathan@gmail.com
Federal College of Education (Technical), Gusau

Abstract

Artificial Intelligence (AI) is revolutionizing education, particularly in assessment and evaluation processes. AI-driven assessments promise efficiency, objectivity, and scalability. However, integrating AI into technology education assessment presents significant ethical challenges, including data privacy, bias, fairness, transparency, and the potential displacement of human educators. This paper explores these ethical concerns, emphasizing the need for a balanced approach that ensures AI is used responsibly. Through an analysis of existing literature, provision for recommendations for ethical AI integration in education, ensuring that assessment remains fair, reliable, and aligned with educational goals are itemized.

Introduction

The rapid advancement of AI has led to its integration into various sectors, including education. AI-powered assessment tools are being increasingly used to evaluate student performance, detect plagiarism, and provide personalized feedback. These technologies offer significant benefits, such as efficiency, scalability, and impartiality. However, ethical concerns surrounding AI-driven assessments have sparked debates among educators, researchers, and policymakers (Luckin *et al.*, 2021).

Technology education is rapidly evolving with the integration of artificial intelligence (AI) in various domains, including assessment. AI-driven assessment tools offer personalized learning experiences, automate grading, and provide real-time feedback, significantly reducing educators' workload (Luckin *et al.*, 2021). However, despite these advantages, the ethical implications of AI-based assessments in education are a growing concern.

The use of AI in assessment raises questions about bias, privacy, transparency, and accountability. Many scholars argue that AI-driven assessments may reinforce existing inequalities, compromise student privacy, and lack the nuanced judgment that human educators provide (Baker & Hawn, 2022). These concerns necessitate a closer examination of AI's role in education to ensure that ethical principles guide its implementation.

This paper examines the ethical challenges associated with AI-driven assessment in technology education. The discussion is structured around key ethical concerns, including bias, data privacy, transparency, accountability, and the role of human educators in AI-assisted learning environments.

Ethical Challenges of AI in Technology Education Assessment

Bias and Fairness

AI systems rely on data to make decisions, and biases in training datasets can lead to discriminatory outcomes (Baker & Hawn, 2022). For example, if an AI assessment tool is trained on data from a particular demographic, it may inadvertently favor students from that group while disadvantaging others. Algorithmic bias can lead to unfair grading, reinforcing existing
inequalities in education.

Fairness in AI-driven assessments requires diverse and representative training data, regular audits, and human oversight to ensure that biases are identified and mitigated (West *et al.*, 2020).

Data Privacy and Security

AI assessment tools collect and analyze vast amounts of student data, raising concerns about privacy and security. Educational institutions must ensure compliance with data protection laws such as the General Data Protection Regulation (GDPR) and the Family Educational Rights and Privacy Act (FERPA) (Selwyn, 2021).

AI-driven assessments should employ robust encryption, anonymization techniques, and secure storage to prevent data breaches and unauthorized access. Transparency regarding data collection, storage, and usage is critical in maintaining student trust (Williamson & Eynon, 2020).

Transparency and Explainability

A significant challenge in AI-driven assessment is the "black box" nature of many AI models, making it difficult for educators and students to understand how decisions are made (Molnar, 2022). When AI tools determine grades or provide feedback, students and instructors should have access to clear explanations of the reasoning behind these decisions.

Explainable AI (XAI) techniques can help make AI-driven assessments more transparent. Developers should prioritize interpretable models and provide detailed documentation on AI decision-making processes (Lipton, 2018).

Accountability and Human Oversight

Determining accountability when AI makes erroneous or unfair assessments is a complex issue. Should responsibility lie with the developers, institutions, or educators? Without clear accountability structures, students may have limited recourse to challenge unfair AI-generated grades (Luckin *et al.*, 2021).

Human oversight is essential to ensure AI-driven assessments align with pedagogical objectives. Educators should have the final say in grading and be able to override AI-generated results when necessary (Ames, 2019).

Bias and Fairness

One of the major ethical concerns in AI-driven assessment is bias. AI models are trained on historical data, and if this data contains biases, the AI may perpetuate them (Baker & Hawn, 2022). For example, standardized test datasets may favor certain demographic groups, leading to unfair scoring for underrepresented populations.

Algorithmic bias in AI-driven assessments can manifest in several ways:

Demographic bias: AI systems may be trained on data that predominantly represents a specific race, gender, or socioeconomic background, leading to unfair grading.

Cultural bias: AI-based assessments may not account for linguistic and cultural differences, disadvantaging students from diverse backgrounds.

Cognitive bias: AI might favor specific learning styles, failing to accommodate students with disabilities or alternative learning needs.

To mitigate bias, developers must ensure diversity in training datasets and conduct regular audits of AI systems (West *et al.*, 2020). Additionally, human oversight is crucial to identify and correct AI-generated biases.

Data Privacy and Security

AI-based assessment tools collect vast amounts of student data, raising concerns about privacy and security. These concerns include:

Unauthorized data access: Cybersecurity threats may expose student data to unauthorized parties.

Data ownership issues: Students and educators may lack clarity regarding who owns and controls assessment data.

Lack of consent: AI-driven assessments often collect data without students fully understanding how it will be used.

Educational institutions must adhere to data protection regulations such as the General Data Protection Regulation (GDPR) and the Family Educational Rights and Privacy Act (FERPA) (Selwyn, 2021). Secure data storage, encryption, and anonymization techniques can help protect student information. Moreover, transparency regarding data collection, storage, and usage is critical in maintaining trust.

Impact on Educators and the Learning Experience

While AI can automate grading and feedback, over-reliance on AI risks dehumanizing education. The role of educators extends beyond assessment; they provide mentorship, critical thinking guidance, and emotional support—roles that AI cannot fully replicate (Selwyn, 2021).

Educators should be involved in designing and monitoring AI-driven assessments to ensure that

they enhance rather than replace human-led learning experiences (Luckin *et al.*, 2021).

Transparency and Explainability

The "black box" nature of AI models presents another ethical dilemma. AI assessment tools often rely on complex algorithms that make it difficult for students and educators to understand how decisions are made (Molnar, 2022). A lack of transparency can lead to issues such as:Unexplainable grades: Students may not understand why they received a certain score.

Lack of recourse: Without clear explanations, students may struggle to challenge incorrect assessments.

Reduced trust: Educators and students may be reluctant to use AI-driven assessments if they cannot interpret the decision-making process.

To address these challenges, developers should prioritize Explainable AI (XAI) techniques, ensuring that AI-generated assessments are interpretable. Additionally, students and educators should be provided with documentation explaining how AI-based assessments function.

Accountability and Human Oversight

A key ethical challenge in AI-driven assessment is determining accountability. If an AI system makes an incorrect assessment or unfair decision, who is responsible? Without clear accountability structures, students may lack recourse to challenge unfair AI-generated grades (Luckin *et al.*, 2021).

The following strategies can enhance accountability:

Human oversight: Educators should have the ability to review and override AI-generated grades.

Ethical AI policies: Institutions should establish policies that define AI accountability and responsibility.

Audit mechanisms: Regular assessments of AI performance should be conducted to identify and correct errors.

Educational institutions must ensure that AI complements, rather than replaces, human decision-making in assessment.

Impact on Educators and the Learning Experience

While AI can automate grading and feedback, over-reliance on AI risks dehumanizing education. The role of educators extends beyond assessment; they provide mentorship, critical thinking guidance, and emotional support—roles that AI cannot fully replicate (Selwyn, 2021).Challenges posed by AI-driven assessment include:

Reduced student-teacher interaction: Overdependence on AI may diminish the personal connection between educators and students.
Job displacement: Automation of assessment tasks could reduce the demand for educators in certain roles.
Standardization of learning: AI may prioritize efficiency over individualized learning experiences.
To prevent these issues, AI should be designed as an assistive tool rather than a replacement for educators. AI-driven assessments should be supplemented with human feedback and guidance.

Addressing Ethical Challenges: Recommendations

To ensure ethical AI integration in technology education assessment, the following recommendations are proposed:
Bias Mitigation: Developers should use diverse datasets and conduct regular bias audits. Institutions should employ fairness-aware AI models.
Data Privacy Protections: AI systems must comply with legal standards such as GDPR and FERPA, employing robust encryption and access controls.
Transparency and Explainability: AI tools should provide interpretable results, with clear documentation and mechanisms for students to challenge decisions.
Human Oversight: AI should assist rather than replace educators. Human intervention should be an integral part of AI-driven assessments.
Ethical AI Policies: Institutions should establish guidelines for ethical AI use, emphasizing accountability and student rights.

Addressing Ethical Challenges: Recommendations

To ensure ethical AI integration in technology education assessment, the following recommendations are proposed:
Bias Mitigation
Use diverse datasets to train AI models.
Conduct bias audits regularly.
Implement fairness-aware algorithms.
Data Privacy Protections
Adhere to GDPR and FERPA regulations.
Use encryption and anonymization techniques.
Provide transparency in data collection and usage.
Transparency and Explainability
Develop Explainable AI (XAI) models.
Provide clear documentation on AI decision-making.
Allow students to challenge AI-generated assessments.
Human Oversight
Maintain human involvement in AI-assisted grading.
Train educators to work with AI assessment tools.
Establish ethical AI governance frameworks.
Ethical AI Policies
Define clear accountability structures for AI errors.
Regularly review AI systems for fairness and accuracy.
Encourage interdisciplinary collaboration between educators, policymakers, and technologists.

Conclusion

AI-driven assessment in technology education offers transformative potential but comes with significant ethical challenges. Addressing bias, ensuring data privacy, promoting

transparency, and maintaining human oversight are critical for the responsible use of AI in education. By adopting ethical AI frameworks, educational institutions can harness AI's benefits while safeguarding fairness, security, and the human elements of learning. AI-driven assessment in technology education offers transformative potential but presents significant ethical challenges. Bias, privacy concerns, lack of transparency, accountability issues, and the changing role of educators must be carefully addressed. Educational institutions must implement ethical AI frameworks to ensure that AI is used responsibly and that assessment remains fair, secure, and human-centered.

By balancing AI-driven efficiency with ethical considerations, we can create an education system that leverages AI's potential while safeguarding fundamental principles of fairness, privacy, and transparency.

References

Ames, M. G. (2019). The charisma machine: The life, death, and legacy of One Laptop per Child. MIT Press.

Baker, R. S., & Hawn, A. (2022). Algorithmic bias in education. Computers & Education, 177, 104384. https://doi.org/10.1016/j.compedu.2021.104384

Lipton, Z. C. (2018). The mythos of model interpretability. ACM Queue, 16(3), 31-57.

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2021). Artificial intelligence and education: Promise and implications for teaching and learning. UNESCO.

Molnar, C. (2022). Interpretable machine learning. Leanpub.

Selwyn, N. (2021). The edtech pandemic boom: A critical assessment of technology-led teaching and learning. Learning, Media and Technology, 46(1), 1-13.

West, S. M., Whittaker, M., & Crawford, K. (2020). Discriminating systems: Gender, race, and power in AI. AI Now Institute.

Williamson, B., & Eynon, R. (2020). Historical trends and contemporary challenges in the ethics of AI and education. Oxford Review of Education, 46(1), 34-47.

INFLUENCE OF ALGORITHM-BASED INSTRUCTIONAL METHODS ON STUDENTS' ACADEMIC ACHIEVEMENT AND INTEREST IN BASIC TECHNOLOGY

[1]Dr. Umar Muhammad Ahmad, [2]Nathaniel Jibrin Usman & [3]Zhiri Deborah
[1]College of Engineering
Umaru Ali Shinkafi Polytechnic, Sokoto
umarmuhdahmad@yahoo.com
+2348036514042
[2]Building Department
Niger State College of Education Minna
dankonath@gmail.com
+2348036879002
[3]Department Of Industrial And Technology Education,
School of technology education, federal university of
Technology minna
+2348036497065

Abstract

The research employed a quasi-experimental design and was conducted in selected secondary schools across Niger State. The study population comprised students from seven secondary schools, from which a sample of 247 Junior Secondary School II students offering Basic Technology was drawn. Two research instruments were utilized: the Basic Technology Achievement Test (BTAT) and the Basic Technology Interest Scale (BTIS). These instruments were validated by three academic experts from the Department of Industrial and Technology Education at the Federal University of Technology, Minna. To ensure reliability, a test-retest procedure was conducted, and the Pearson Product Moment Correlation Coefficient yielded strong reliability indices of 0.85 for BTAT and 0.88 for BTIS. The administration of the instruments was carried out by the researcher, assisted by two trained research aides. Data were collected through both pre-test and post-test administrations of the BTAT and BTIS. The collected data were analyzed using Mean and Standard Deviation to address the research questions, while Analysis of Covariance (ANCOVA) was employed to test the two null hypotheses at a 0.05 level of significance. The study's findings indicated that the use of algorithm-based instructional strategies significantly improved students' academic performance in Basic Technology compared to the traditional lecture method. Furthermore, the approach also enhanced students' interest in the subject more effectively than conventional teaching methods. In conclusion, the study highlighted that the prevailing low levels of achievement and interest in Basic Technology among students necessitated the investigation into the impact of algorithm-based instructional methods within secondary schools in Niger State.

Keywords: Algorithm-based, instructional methods, students, basic technology, achievement, interest

Introduction

Science is fundamentally a dynamic discipline that involves the systematic pursuit of knowledge about the natural world through observation and experimentation (Anaekwe *et al.,* 2009). Science education, more specifically, refers to the structured training and acquisition of scientific understanding through careful observation and analysis of phenomena, equipping

individuals to participate meaningfully in society (Ifeakor & Okoli, 2021). According to Ukah (2023), science education serves as both a social process and a platform for acquiring essential knowledge, skills, and attitudes necessary for scientific literacy. In a similar vein, Ellah (2024) defines science education as the comprehension of scientific concepts and processes that empower individuals to make informed decisions and engage in societal development. Recognizing the significance of science education, Nigeria like many other nations prioritizes it across all educational levels, including secondary education. The National Policy on Education (Federal Republic of Nigeria [FRN], 2024) outlines the objectives of post-basic education, which include the provision of trained manpower in applied sciences, technology, and commerce at sub-professional levels, as well as the development of entrepreneurial, technical, and vocational competencies essential for self-reliance and for advancing agriculture, commerce, and the broader economy.

The science subjects are very important in providing trained manpower in the applied sciences, technology and commerce at sub-professional grades and entrepreneurial, technical and vocational job-specific skills for self reliance. Their importance in preparing professionals such as chemistry, biology and physics teachers, doctors, pharmacists, agricultural scientists, biologist, engineers and many other professions cannot be overemphasized. Raina (2021) posits that the study of these science subjects also equips its beneficiaries with necessary knowledge; skills and attitudes to enable them interact meaningfully with their environment, solve every day problems and live successfully in this day of advancing science and technology.

Raina emphasizes that the present educational framework in Nigeria, which prioritizes self-reliance and sustainable national development, is fundamentally anchored on science and technology, with a strong focus on core science subjects such as Chemistry, Physics, and Biology. Supporting this view, Agbi (2025) asserts that the knowledge gained from science subjects plays a critical role in various sectors, including manufacturing, processing, and the development of construction materials, pharmaceuticals, water systems, food products, fertilizers, insecticides, and herbicides. The Nigerian government has consistently demonstrated its commitment to advancing science education, recognizing its relevance to civic engagement, cultural development, and economic sustainability in an ever-evolving world. Science education encompasses a range of investigative processes aimed at the acquisition, development, and application of scientific knowledge and skills, thereby enhancing productivity and shaping individuals' attitudes toward environmental and natural phenomena. Accordingly, one of the core objectives of science education is to equip learners with a comprehensive understanding of the complexities of the physical world and to cultivate values that promote a meaningful and virtuous life (Federal Republic of Nigeria, 2024). Globally, it is widely acknowledged that science and technology are pivotal to human advancement, as they provide solutions to essential needs such as food security, potable water, shelter, energy, healthcare, and education. In Nigeria, concrete efforts have been made to reinforce the significance of science education. These include the establishment of specialized institutions such as universities of agriculture and technology, polytechnics, and colleges of technology; the implementation of the 60:40 university admission policy in favor of science-based applicants; and the creation of special science secondary schools by various state governments. Moreover, the proactive engagement of professional organizations such as the Science Teachers Association of Nigeria (STAN), the Chemical Society of Nigeria (CSN), the Nigerian Institute of Physics (NIP), and the Nigerian Society of Biochemistry and Molecular Biology (NSBMB) reflects a collective commitment among stakeholders to promote the effective teaching and learning of science subjects in Nigerian schools.

Basic technology curriculum adapted a spiral approach of teaching which expressed the fundamental unity of scientific thought. It is expected that by teaching Basic technology at these level, every Nigerian student would be given the basic knowledge and understanding of what science is all about and exposed to some of the innovations that are taking place around them. This assertion blends with the objectives of science teaching which are to produce individuals who will be able to live effectively in the modern age of science and technology and contribute to the development of the nation (Agogo & Ode, 2021).According to the National Curriculum for Junior Secondary School (FRN, 2022),basic technology is aimed at enabling students acquire specific science process skills such as: observing, organizing acquired information, generalizing on the basis of acquired information, predicting as a result of generalization and designing experiment (including controls where necessary) to check predictions. Olusi (2018) earlier shown that concrete steps ought to betaken to get students groomed or trained in science and technology to enable them use scientific facts to interpret natural phenomena such as earthquake, volcanoes and other natural disasters. This may ultimately help them in solving environmental challenges. But the teaching of basic technology is faced with myriads of challenges. For instance, the subject is handled by teachers who are single subject specialist either in biology, chemistry, physics, integrated science or agricultural science, taught in an ill-equipped classroom, library and laboratory, without teaching aid. Some of these claims are verifiable because they might not have anything to do with disparity in achievement of students in BECE Basic technology as it relates to their performance in science at senior secondary education level.

The successful realization of the objectives of Basic Technology Education and the improvement of students' academic performance in secondary schools are influenced by several critical factors. Among these is the inability of the current Basic Technology curriculum to adequately address the practical demands of daily life, societal comfort, and the nation's technological advancement (Akinpade *et al.*, 2020). Additional barriers include a shortage of qualified teachers, ineffective instructional methods, and insufficient teaching materials and infrastructure (Amaechi & Thomas, 2016). In terms of teacher quality and availability, existing literature suggests a significant shortfall of trained professionals capable of effectively delivering Basic Technology Education in Nigerian secondary schools. Beyond the numerical gap, many educators also lack the necessary pedagogical competencies to facilitate meaningful learning. Furthermore, deficiencies in technical mastery of subject content are prevalent among instructors (Oviawe *et al.*, 2017; Bashir, 2018). Umar *et al.* (2020) argue that all technical and vocational education programs must be properly implemented to address both economic and environmental demands posed by evolving professional tasks. These tasks are intricately linked to technological advancements within industries, rendering outdated, analog methods obsolete and necessitating the acquisition of advanced, often sophisticated, skill sets. Consequently, there is a pressing need for the training of Basic Technology artisans who are adaptable and capable of meeting the dynamic challenges of modern industry and technology.

Given the rapid evolution of technology and the accompanying challenges, it has become increasingly essential to prepare Basic Technology Education students to meet these demands. This necessity calls for a paradigm shift from traditional instructional methods rooted in behavioral learning theories to more contemporary approaches based on cognitive psychological principles among which the design-thinking learning strategy stands out (Pusca & Northwood, 2018; DeGone, 2021). Supporting this shift, William (2019) argued that despite years of educational reforms, the pace of global technological advancement and shifting societal conditions continuously compels nations to rethink and modernize their teaching and learning strategies in alignment with the demands of the 21st century. According

to Mohammed and Iredje (2020), the instructional strategies employed by educators significantly influence students' learning outcomes. Design thinking is emerging as a dynamic instructional approach aimed at equipping students with essential 21st-century thinking and problem-solving skills, thereby supporting both academic and career readiness. As Pusca and Northwood (2018) noted, design-thinking operates as a human-centered, open-ended, and problem-based framework that transforms teaching and learning practices. It is particularly effective in addressing the multifaceted challenges educators and learners face within digital learning environments and outcome-based curricula. Furthermore, design-thinking has demonstrated significant utility in solving complex, ill-structured, or ambiguous problems (Fabiano *et al.*, 2021), making it a valuable tool for modern educational practice.

Algorithm-based instructional methods represent a fast-advancing field in educational technology with immense potential to influence various aspects of society. As a branch of Artificial Intelligence (AI), these methods enable systems to improve performance through experience, without the need for direct programming. By employing a data-driven approach, algorithm-based methods can autonomously detect patterns and extract insights from data, subsequently using these insights to make informed predictions or decisions. The growing accessibility of large-scale data has positioned algorithm-based instructional strategies as one of the most promising domains in current educational research and innovation. A report by Markets and Markets (2020) projects that the global market for algorithm-based instructional methods will grow from $1.4 billion in 2020 to $10.9 billion by 2025, reflecting a compound annual growth rate (CAGR) of 44.1%. These instructional methods are already transforming numerous sectors, including education, healthcare, finance, transportation, and manufacturing. In the healthcare sector, for instance, algorithm-based models are enhancing diagnostic precision, forecasting patient outcomes, and customizing treatment plans. Within the financial industry, they are instrumental in identifying fraudulent transactions, assessing credit risks, and refining investment strategies. Despite these significant benefits, concerns persist regarding their potential societal drawbacks particularly in areas such as job displacement and the erosion of privacy. As a result, there is a growing demand for in-depth research to examine both the advantages and the societal implications of these technologies. The goal of this study is to provide a comprehensive assessment of the current and projected impact of algorithm-based instructional methods on society. This includes an extensive literature review, detailed case studies, and survey-based investigations focusing on economic effects, ethical and privacy considerations, as well as public perceptions. The findings from this research will offer valuable insights into the prevailing trends and future outcomes associated with algorithm-based instructional strategies. This information will aid policymakers, scholars, and practitioners in making thoughtful and evidence-based decisions regarding the adoption and application of these technologies. Furthermore, the study aims to inform the public about both the benefits and potential risks of algorithm-based methods, helping to foster understanding and address any prevailing concerns.

Student Academic achievement has to do with the successful accomplishment of goals, measured by the extent to which instructional objectives are achieved. According to Eze and Osuyi, (2018), academic achievement is a measure of the degree of success in performing specific tasks in a subject area or area of study by students after a learning experience. Whereas Ahmad and Ombuguhim, (2020) defined achievement as the scholastic standing of a student at a given moment in learning both theoretical and practical skills in Basic technology therefore, is essential to students' progress in the changing world of technology. In this regard, effective instructional approach must be developed to improve skills achievement and to maintain acquired skills at a functional level over a period of time. With adoption of

design-thinking learning strategies, students' interest might increase. When students' interests are piqued, their performance improves.

Student interest according to Duru *et al.* (2021) is defined as a content-specific, person-object relationship that emerges from an individual's interaction with the environment. According to the authors, interest is an important variable in the school context, as it can influence students' level of participation in learning, Self-efficacy of their learning experience as well as their level of performance. The study therefore poised to find out the effect of Algorithm-based instructional methods on students' achievement and interest in basic technology in Niger State.

Statement of the Problem

Basic Technology is one of the vocational subjects offered at the secondary school level, designed to equip students with practical and theoretical skills necessary for self-reliance after graduation. These skills include, but are not limited to, the ability to interpret technical drawings, execute foundational construction tasks such as setting out buildings, forming block walls on concrete foundations, leveling structures, and designing functional and aesthetically pleasing roofing systems.

Despite the relevance of the subject, reports from the National Examinations Council (NECO) consistently indicate low student performance in Basic Technology. This persistent underachievement has been largely attributed to the use of ineffective pedagogical approaches by teachers. For instance, a study by Mbonyiryivuze *et al.* (2019) revealed that students' academic struggles are closely linked to the teaching methods employed in the classroom. Similarly, scholars such as Duhu and Ibanga (2020), as well as Lawal *et al.* (2020), identified multiple contributors to students' poor performance in Basic Technology. These include student-related factors, teacher-related factors, societal influences, and government-related issues.

Among the teacher-related factors, the continued reliance on conventional instructional methods remains a significant concern. As Ayonmike (2020) noted, the persistent use of outdated teaching strategies often leads to student disengagement and absenteeism, which in turn negatively affects learning outcomes.

While various interventions have been proposed to address students' poor performance, many remain underutilized. Consequently, there is a pressing need to explore innovative, learner-centered approaches that cater to individual differences and foster deeper engagement. One such promising strategy is the algorithm-based instructional method, which aligns with the principles of design-thinking. This approach emphasizes problem-solving, creativity, and adaptability skills essential for the modern learner. Therefore, this study aims to investigate the effect of algorithm-based instructional methods on students' academic achievement and interest in Basic Technology in secondary schools across Niger State.

Research Questions

The following research questions guided the study:

1. What are the mean achievement scores of students taught Basic technology using Algorithm-based instructional methods and those taught using lecture method in Niger State?
2. What are the mean interest scores of students taught Basic technology using Algorithm-based instructional methods and those taught using lecture method in Niger State?

Hypotheses

The following null hypotheses were formulated and tested a 0.05 level of significance.

Ho_1: There is no significant difference in the mean achievement scores of students taught Basic technology using Algorithm-based instructional methods and those taught using lecture method in Niger State.

Ho_2: There is no significant difference in the mean interest scores of students taught Basic technology using Algorithm-based instructional methods and those taught using lecture method in Niger State.

Methodology

The study employed a quasi-experimental research design and was conducted in selected secondary schools within Niger State. The target population comprised students from seven secondary schools, with a sample size of 247 Junior Secondary School II (JSS II) students offering Basic Technology. Two instruments were used for data collection: the Basic Technology Achievement Test (BTAT) and the Basic Technology Interest Scale (BTIS). These instruments were validated by three experts from the Department of Science Education, Federal University of Technology, Minna. To determine their reliability, a test-retest procedure was conducted, and the Pearson Product Moment Correlation Coefficient yielded reliability coefficients of 0.85 for BTAT and 0.88 for BTIS, indicating a strong positive correlation. The instruments were administered by the researcher with the assistance of two trained research aides. Data were collected in two phases pre-test and post-test using the BTAT and BTIS. Following the administration of the pre-test, the items on the BTAT were reshuffled before being used again in the post-test to prevent students from relying on memorized answers. This step was taken to ensure the integrity and reliability of the test outcomes. The data obtained from both test phases were analyzed using Mean and Standard Deviation to answer the research questions. Additionally, Analysis of Covariance (ANCOVA) was employed to test the two null hypotheses at a 0.05 level of significance. The choice of ANCOVA was informed by its ability to adjust for initial group differences, especially since intact classes (rather than randomized groups) were used in the study. The pre-test scores served as a covariate to control for potential pre-existing differences between the experimental and control groups, further justifying the appropriateness of ANCOVA for hypothesis testing.

Results

Research Question 1: What are the mean achievement scores of students taught Basic technology using Algorithm-based instructional methods and those taught using lecture method?

Table 1: Mean Achievement Scores of Students taught Basic technology using Algorithm-based instructional methods and those taught using Lecture Method

Teaching Methods	N	Pre-test		Post-test		Mean Gain Score
		Mean	SD	Mean	SD	
Algorithm-based instructional methods	126	33.28	10.32	79.08	8.80	42.80
Lecture Method	121	33.62	6.20	37.77	7.25	4.15
Total	**247**	**33.45**	**8.26**	**58.43**	**8.03**	**23.48**

Table 1 showed that students taught Basic technology in junior secondary schools using Algorithm-based instructional methods had a mean and standard deviation achievement score of 33.28 (10.32) in pre-test while students taught with lecture method had pretest mean and standard deviation achievement score of 33.62 (6.20) respectively. This suggests that at pretest level students in both design thinking based and lecture methods almost had the same achievement. The post-test mean and standard deviation achievement of students taught Basic technology in junior secondary schools using the design thinking based and lecture methods

are 79.08 (8.80) and 37.77 (7.25) respectively. This implies that students taught Basic technology in junior secondary schools with design thinking based had better achievement than their counterparts taught using the lecture method. Thus, the Algorithm-based instructional methods enhances students' achievement in Basic technology in junior secondary schools more than the lecture method.

Research Question 2: What are the mean interest scores of students taught Basic technology using Algorithm-based instructional methods and those taught using lecture method?

Table 2: Mean Interest Scores of students taught Basic technology using Algorithm-based instructional methods and those taught using lecture method

Teaching Methods	N	Pre-test		Post-test		Mean Gain Score
		Mean	SD	Mean	SD	
Algorithm-based instructional methods	126	1.69	0.80	3.39	0.68	1.70
Lecture Method	121	1.55	0.62	1.76	0.75	0.21
Total	**247**	**1.62**	**0.71**	**2.58**	**0.72**	**0.95**

Table 2 revealed that students taught Basic technology in junior secondary schools using Algorithm-based instructional methods had a mean and standard deviation interest score of 1.69 (0.80) in pre-test while students taught with lecture method had pretest mean and standard deviation interest score of 1.55 (0.62) respectively. This suggests that at pretest level students in both Algorithm-based instructional methods and lecture method almost had the same interest level. The post-test mean and standard deviation interest of students taught Basic technology in junior secondary schools using the design thinking based and lecture methods are 3.39 (0.68) and 1.76 (0.75) respectively. This implies that students taught Basic technology in junior secondary schools with design thinking based had higher interest in Basic technology than their counterparts taught using the lecture method. Thus, the Algorithm-based instructional methods promotes students' interest in Basic technology in junior secondary schools more than the lecture method.

Ho_1: There is no significant difference in the mean achievement scores of students taught Basic technology using Algorithm-based instructional methods and those taught using lecture method.

Table 3: ANCOVA Summary Table of the difference in the mean (x) achievement scores of students taught Basic technology using Algorithm-based instructional methods and those taught using lecture method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	109046.255[a]	2	54523.128	1081.545	.000
Intercept	28358.581	1	28358.581	562.534	.000
Pretest	3708.140	1	3708.140	73.556	.000
Method	**106104.674**	**1**	**106104.674**	**2104.740**	**.000**
Error	12300.587	244	50.412		
Total	976558.000	247			
Corrected Total	121346.842	246			

Table 3 shows the F value as 2104.74 and the probability value as .000. The probability value of .000 of this finding is less than the alpha value of 0.05. Therefore, the null hypothesis is rejected and thus, there is significant difference in the mean achievement scores of students taught Basic technology using Algorithm-based instructional methods and those taught using lecture method in favour of the Algorithm-based instructional methods. This implies that students taught Basic technology with Algorithm-based instructional methods had better achievement compared with their counterparts taught with the lecture strategy.

Ho2: There is no significant difference in the mean interest scores of students taught Basic technology using Algorithm-based instructional methods and those taught using lecture method.

Table 4: ANCOVA Summary Table of the difference in the mean (x) interest scores of students taught Basic technology using Algorithm-based instructional methods and those taught using lecture method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	165.925[a]	2	82.963	163.546	.000
Intercept	313.734	1	313.734	618.469	.000
Pre-Interest	2.219	1	2.219	4.374	.038
Method	**165.854**	**1**	**165.854**	**326.950**	**.000**
Error	123.775	244	.507		
Total	1948.000	247			
Corrected Total	289.700	246			

Table 4 showed the F value as 326.95 and the probability value as .000. Since the probability value of .000 of this finding is less than the alpha value of 0.05. Therefore, the null hypothesis is rejected and thus, there is a significant difference in the mean interest scores of students taught Basic technology using Algorithm-based instructional methods and those taught using lecture method in favour of the Algorithm-based instructional methods. This suggests that students taught Basic technology with the Algorithm-based instructional methods had higher interest in the subject compared to their counterparts taught with the lecture method.

Discussion of Results

The data presented in Tables 1 and 3 indicate that junior secondary school students who were taught Basic Technology using design-thinking-based instructional strategies, specifically algorithm-based methods, achieved higher academic performance compared to their peers who were taught using the conventional lecture method. The results show a significant difference in the mean achievement scores between the two groups, favoring those exposed to algorithm-based instructional methods. This outcome suggests that students' direct engagement in learning activities an inherent feature of algorithm-based strategies significantly enhances academic achievement over traditional, teacher-centered approaches.

This finding aligns with the study by Fabiano *et al.* (2021), which demonstrated that algorithm-based instructional methods are highly effective in improving students' academic performance and knowledge retention, particularly among younger learners.

Similarly, Table 2 addressed the second research question, while Table 4 provided statistical evidence for testing the second hypothesis. The analysis revealed that students taught Basic Technology using algorithm-based instructional methods exhibited greater interest in the

subject compared to those taught through the lecture method. A significant difference was observed in the mean interest scores, again favoring the algorithm-based group.

This outcome reinforces the understanding that active student participation in the learning process fosters deeper engagement and interest, while minimizing classroom disengagement, boredom, and inattention. The findings of this study resonate with those of Cereja *et al.* (2018), who found that learners exposed to design-thinking approaches demonstrated significantly higher interest in Technical Drawing than their counterparts taught using traditional lecture-based instruction.

In essence, the study underscores the value of learner-centered, algorithm-based instructional strategies in not only enhancing academic achievement but also in stimulating interest among students in Basic Technology a subject critical for vocational readiness and technological literacy in Nigeria's secondary education system.

Conclusions

Students' poor achievement and interest in Basic technology informed the need for the study on the effect of Algorithm-based instructional methods on students' achievement and interest in Basic technology in Secondary Schools in Niger state. The study indicated that Algorithm-based instructional methods enhances students' achievement and interest in Basic technology more than the lecture method. Basically, there was significant difference in the mean achievement and interest scores of students taught Basic technology using Algorithm-based instructional methods and those taught using lecture method in favour of the Algorithm-based instructional methods. It was concluded that appropriate use of Algorithm-based instructional methods in teaching Basic technology would facilitate students' achievement and interest in Basic technology.

Recommendations

Based on the findings of the study, the following recommendations were made.

1. Basic technology teachers should be encouraged by the government through its relevant ministries to adopt Algorithm-based instructional methods in teaching and learning Basic technology for better academic achievement of the students in the subject.
2. The Government through its relevant ministries of education should organize seminars, workshops and symposia for the in-service teachers on the use of Algorithm-based instructional methods for effective teaching and learning of Basic technology in junior secondary schools.

References

Ahmad, T. A., & Ombuguhim, S. U. (2020). Effect of Self-Regulatory Learning Strategy on Students' Achievement in Basic technology in Minna, Niger State. *Journal of Information, Education, Science and Technology,* 6(2), 122-131.

Akinpade, O. A., Alawode, O. D. & Usman, G. A. (2020). Assessment of Workshop Facilities for Effective Teaching - Learning Delivery in Industrial and Technology Education Department. Federal University of Technology, Minna. *Journal of Information Education, Science and Technology,* 6 (1), 62-67.

Amabile, T. M. (2018). Creativity in Context: Update to the Social Psychology of Creativity. New York: Routledge.

Amaechi, O.J, & Thomas, C.G. (2016). Strategies of effective teaching and learning Practica skills in technical and vocational training programmes in Nigeria. *International Journal of Scientific Research Engineering & Technology (IJSRET), 5*(12), 598-603.

Ayonmike, C. S. (2020). Strategic work-based learning framework for achieving sustainable development goals(SDG) through global partnership in TVET. *Journal of Information Education, Science and Technology,* 6 (1), 89-97.

Barroca, A., & Soares, J. (2017). Design Thinking Mindset Applied to Education and Training. *INTED2017 Proceedings*. doi:10.21125/inted.2017.

Bashir, M. (2018). Adequacy and utilization of instructional materials for teaching electrical installation and maintenance work trade in Adamawa State Secondary Schools. *ATBU Journal of Science, Technology & Education (JOSTE), 6*(2*),* 226-233.Retrieved April 24, 2019, from: www.atbuftejoste.com

Cereja, J. R., Santoro, F. M., Gorbacheva, E., & Matzner, M. (2018). Application of the Design Thinking Approach to Process Redesign at an Insurance Company in Brazil. In Business Process Management Cases (pp. 205-233): *Springer*.

DeGone, B. (2021). The Impact of Project-Based Learning on Students in High School Chemistry in Rural Maine. Electronic Theses and Dissertations. 3504. https://digitalcommons.library.umaine.edu/etd/3504.

Duhu, P.C. & Ibanga, I. J. (2020). Effects of Guided Discovery Method of Teaching on Students' Academic Achievement and Retention in Electrical Installation and Maintenance Work in Government Secondary Schools of Adamawa State. *Journal of Information, Education, Science and Technology,* 6 (2), 43-50.

Duru, P. T., Nwankwo, F., Motanya, C., Aliyu, M. & Rabiu, M. B. (2021). Effects of Science Process Skills on Achievement and Interest of Pre-service Biology Teacher's in College of Education, Minna Niger State, Nigeria. *International Journal of Industrial Technology, Engineering, Science and Education,* 2(1), 98-104. *Educational Technology*, 33-52. Doi:https://doi.org/10.14742/ajet.6667.

Eze, T. L. & Osuyi, S.O. (2018), "Effect of Problem-based Teaching Method on Students' Academic Performance in Electrical Installation and Maintenance Works in Secondary Schools in Edo State", *International Journal of Development and Sustainability,* 7(2), 666-678.

Fabiano, P. N., Marcos M., Francisco Antonio Pereira, F. & Carolina, (2021). Design Thinking as A Tool to The Teaching of Children, And Teachers In The 21st Century: An Integrative Review. *International Journal for Innovation Education and Research,* 9(11)131-146

Federal Republic of Nigeria (FRN) (2013). *National Policy on Education* (6th edition). Lagos: National Educational Research and Development Council (NERDC) Press.

Idris, N. B. (2019). Malaysia. *Issues in Upper Secondary Science Education*. doi:10.1057/9781137275967.0010

into Instructional Design: The Open Teach case study. *Australasian Journal of*

Kudu, B. U. & Beji, D. B. (2018). Development and Validation of Training Manual for Block, Bricklaing and Concreting Students in Technical Clooeges in Nigeria. *International journal of industrial technology, engineering, science and education,* 1(1), 81-86.

Lawal, G., Aniah A., & Alabi, T. O. (2020). The Perception, Attitudes and Readiness Towards Online Learning among College of Education Pre-service Teachers in Katsina State, Nigeria. *Journal of Information, Education, Science and Technology,* 6(2), 132-138.

Markets and Markets, (2020). "Algorithm-based instructional methods Market by Component (Solutions and Services), Application (Image Recognition, Natural Language Processing, and Predictive Maintenance), Deployment Model, Organization Size, Industry, and Region - Global Forecast to 2025," ResearchAndMarkets.com. [Online].

Available: https://www.researchandmarkets.com/reports/4625991/machine-learning-market-by-component-solutions-and.

Mbonyiryivuze, A., Yadav, L.L., & Amadalo, M.M. (2019). Students' conceptual Understanding of electricity and magnetismand its implications: A review. African *Journal of Educational Studies in Mathematics and Sciences.*15(2), 55-67. doi: https://dx.doi.org/10.4314/ajesms.v15i2.5.

Mohammed, R. E., & Iredje, N. (2020). Effects of Target Task Model and Experiential Learning Approach on Senior Secondary School Students' Performance in Physics. *Journal of Science, Technology, Mathematics and Education,* 16(2), 186-197. national development. *Benue State University Journal of Education,* 19(1), 17-23

Oviawe, J.I., Uwameiye, R., & Uddin, P.S.O. (2017). Bridging skill gap to meet technical, vocational education and training school-workplace collaboration in the 21stCentury. *International Journal of Vocational Education and Training Research,* 3(1), 7-14. doi: 10.11648/j.ijvetr.20170301.12.

Pande, M., & Bharathi, S. V. (2020). Theoretical foundations of design thinking–A constructivism learning approach to design thinking. *Thinking Skills and Creativity, 36(3),* 10-26.

Pusca, D. & Northwood, D. O. (2018). Design Thinking and its Application to Problem Solving. *Global Journal of Engineering Education,* 20, (1) 48-53.

Shé, C. N., Farrell, O., Brunton, J., & Costello, E. (2021). Integrating Design Thinking students in building construction trade in Secondary Schools in Nigeria for

Tema, J. T. & Dauda, G. (2018). Assessment of the cognitive skills performance of

Umar, B. K., Alhassan, N. U. & Nathaniel, J. U. (2020). Entrepreneurship Skills Needed by Blocks, Bricklaying & Concreting in Technical College Graduates in Niger State. *Journal of Information, Education, Science and Technology,* 6(2), 89-93

William, X. T. (2019). 21st Century Learning Skills in Education and Employability. A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Education to the Faculty of the Department of Administrative and Instructional Leadership of the School of Education St. John's University, New Yor

PERCEPTION OF VIRTUAL REALITY AS AN INSTRUCTION TOOL AMONG PRESERVICE TVET TEACHER EDUCATORS IN TERTIARY INSTITUTIONS IN RIVERS STATE

[*1]Legborsi Nwineh (PhD), [2]Ekwueme Orikoha (PhD) and [3]Kelechi Casmir Ezinma
[1&2]Department of Vocational and Technology
Education Rivers State University, Port Harcourt
[3]Industrial Training Fund
*Correspondence author email: nwineh.legborsi@ust.edu.ng

Abstract

Understanding preservice TVET teacher educators' perception on the usefulness of virtual reality is key to integration and effective preparation of TVET teachers for utilization of the technology. The study investigated preservice TVET teacher educators' perception of virtual reality in tertiary institutions in Rivers State. Four research questions guided the study. A descriptive survey research design was adopted with a total of 52 study participants. Data were collected using a validated questionnaire with internal consistency coefficient of 0.89. Data gathered were analysed with mean. Result showed that the respondents had positive perception on the usefulness of virtual reality in motivating students for learning in technical education programme. Similarly, the preservice TVET teacher educators had positive perception of the usefulness of virtual reality in helping students gain knowledge in technical education programme. It was further found perceived some challenges that could limit effective usage of virtual reality for instructional delivery in technical education programme. Generally, it was concluded that although the preservice TVET teacher educators perceive virtual reality to be a useful instructional tool for technical education programme, there is need for consideration of the potential challenges. Based on the findings, it was recommended among others that virtual reality should be adopted in the teaching and learning of practical content in technical education.

Keywords: Virtual reality, augmented reality, technical and vocational education, instructional delivery, perception of virtual reality, usefulness of virtual reality.

Introduction

The integration of digital technologies into education offers significant benefits for instructional delivery across all levels of the educational sector. In light of this, over time, institutions of learning have gradually embraced emerging technologies to enhance teaching and learning towards preparing students for the modern workplace. Integration of emerging technologies is particularly critical in Technical and Vocational Education and Training (TVET), which emphasizes hands-on skills and practical competencies. Among the different of technologies gaining attention in this TVET, Virtual Reality (VR) stands out as an important tool for enhancing instructional delivery.

Virtual reality refers to a three-dimensional computer simulation of the environments which users can interact with using special electronic devices including headsets, gloves, or motion sensors (Radianti *et al.,* 2020).

Virtual reality (VR) applications in Technical and Vocational Education and Training (TVET) can be grouped into immersive and non-immersive virtual reality applications. The immersive or full immersive virtual reality applications are the most advanced form.

They utilize head-mounted displays (HMDs) and motion-tracking technology to transport users into completely virtual environments with 360-degree experiences (Freina & Ott, 2015). Some systems also integrate augmented reality (AR) and mixed reality (MR) to blend real-world and virtual elements, expanding the spectrum of possibilities for instructional innovation in TVET. They are widely used to replicate real-world technical tasks such as welding, automotive repair, and electrical work. They provide learners with opportunity to practice skills in a safe, risk-free environment and repeat procedures as needed for mastery (Abdul Hamid *et al.,* 2024; Leong, 2024). Non-immersive VR uses standard computer screens to simulate environments, allowing interaction through conventional devices like keyboards and mice. Examples are virtual laboratories, Scenario-based VR and educational VR games among others. Virtual laboratories provide opportunities for experimentation and skill development without the hazards or costs associated with physical labs. They are particularly, useful healthcare, engineering, and science (Leong, 2024; Smutny, 2022). Scenario-based VR training which enable learners to develop soft skills such as teamwork, communication, and customer service through interactive, lifelike situations (Leong, 2024). Educational VR games combine gamification with skill acquisition to boost engagement and learning outcomes (Oyelere *et al.,* 2020).

Virtual reality offers significant benefits in education as it can improve motivation, engagement, motivation, retention, and skill acquisition and learning outcomes, particularly when technical and pedagogical barriers are properly addressed and aligned with instructional goals (Lampropoulos & Kinshuk, 2024; Radianti *et al.,* 2020; Parong & Mayer, 2018). In Technical and Vocational Education and Training (TVET), virtual reality offers immersive, interactive environments that closely simulate real-world scenarios. VR allows learners to practice technical skills in a risk-free setting. It also provides opportunity for repeated practice and error correction without the hazards or costs associated with traditional hands-on training (Leong, 2024). Virtual reality provides learners opportunity to visualize complex procedures and operations and as a result of this, enhances learner engagement, motivation, and retention (Allcoat *et al.,* 2021; Leong, 2024; Makransky *et al.,* 2019). VR also makes learning more accessible to different categories of learners such as those with disability, those located in remote areas as well as those with limited resources (Leong, 2024; Rajamanickam *et al.,* 2024). Empirical evidence shows that VR has positive effect on psychomotor skills, knowledge acquisition, and spatial abilities, which are essential in TVET (JulianAbich *et al.,* 2021). Additionally, VR can be tailored to meet evolving industry demands (Leong, 2024; Rajamanickam *et al.,* 2024). Although issues such as cost particularly initial cost of deployment, infrastructure, and instructor training are notable, integrating VR into TVET presents opportunity for effective delivery (Leong, 2024; Rajamanickam *et al.,* 2024; JulianAbich *et al.,* 2021; Allcoat *et al.,* 2021).

A number of empirical studies have been conducted on preservice TVET teachers' and educators' perception on virtual reality (Antón-Sancho *et al.,* 2024; Baxter and Hainey, 2019; Criollo-C *et al.,* 2024; Domingo & Bradley, 2018; Cooper *et al.,* 2019; Farsi *et al.,* 2023; Hagge, 2020). However, studies which specifically focused on perception of preservice TVET teachers and or preservice TVET teacher educators in tertiary institutions in Nigeria were scarce in the literature. Cooper et al. (2019) investigated the pre-service teachers' perceptions about VR, Specifically, the study examined their beliefs about the capacity of VR as a teaching and learning tool. The result of the study showed that participants were interested in VR, they perceived that VR was very engaging and

would have positive effect on learning. They were also willing to use VR. Another study by Domingo and Bradley (2018) investigated the perception of master of arts preservice teachers on the use and value of virtual reality. The result showed that students had positive perception about the usefulness of virtual reality. Similar results were obtained by Antón-Sancho *et al.*, 2024, Criollo-C et al. (2024), Farsi et al. (2023), Hagge (2020), Baxter and Hainey (2019) and Lund and Wang (2019). There is need therefore to understand how TVET teacher educators perceive virtual reality.

Understanding how lecturers and students perceive VR as an instructional tool is essential for effective integration and sustainability of the technology in educational settings. Their perceptions can influence not only the adoption of VR tools but also their effective utilization and pedagogical alignment. If students perceive virtual reality to be engaging, useful, and aligned with their learning needs, they are more likely to embrace and benefit from it. Similarly, lecturers' perceptions affect how confidently and effectively they would be willing to and eventually incorporate VR into their instructional delivery (Bower *et al.*, 2020). In TVET, where experiential learning and technical competences are paramount, aligning perceptions with instructional outcomes can foster meaningful technology adoption and optimum student achievement. This study is significant because it addresses a growing gap in the literature regarding the perception and readiness of TVET educators to adopt VR as an instructional tool. By investigating TVET teacher educators' perceptions on virtual reality in tertiary institutions, the study offers evidence to guide institutional decision-making, capacity-building, and policy formulation for educational innovation in TVET.

Purpose of the Study and Research Questions

The purpose of this study was to investigate the perception of virtual reality as an instruction tool among preservice TVET Teacher educators and students in tertiary institutions in Rivers State. To address this purpose, three research questions guided the study which are as follows.

1. What are the preservice TVET teacher educators' perception of the ease of use of virtual reality for instructional delivering in technical education programme in tertiary institutions in Rivers State?
2. What are the preservice TVET teacher educators' perception of the usefulness of virtual reality in motivating students for learning in technical education programme in tertiary institutions in Rivers State?
3. What is the preservice TVET teacher educators' perception of the usefulness of virtual reality in helping students gain knowledge in technical education programme in tertiary institutions in Rivers State?
4. What are the preservice TVET teacher educators' perception of the challenges associated with the use of virtual reality for instructional purpose in technical education programme in tertiary institutions in Rivers State?

Methodology

The study adopted a descriptive survey research design. The sample for the study was 52 which comprised preservice TVET teacher educators from three tertiary institutions (Rivers State University, Ignatius Ajuru University of Education and Federal College of Education (Technical) Omoku that offer technical education programme in Rivers State. Instrument for data collection was a validated survey questionnaire which was which had

internal consistency reliability coefficient of .89 obtained through Cronbach Alpha. The respondents were requested to indicate their perception of the usefulness of virtual reality as a tool for instructional delivery, usefulness of virtual reality in motivating students for learning in technical education programme, usefulness of virtual reality in helping students gain knowledge in technical education programme and their perception of the challenges associated with the use of virtual reality for instructional purpose in technical education programme. The responses were structured on a four-point rating scale ranging from Strongly Disagreed (SD) with a score of 1, Disagreed (D) with a score of 2, Agreed (A) with a score of 3 and Strongly Agreed (SA) with a score of 4. A total of 52 copies of the instrument was administered and a total of 52 was retrieved and used for data analysis. Data gathered were analysed using mean.

Result

Research Question 1: What are the preservice TVET teacher educators' perception of the ease of use of virtual reality for instructional delivering in technical education programme in tertiary institutions in Rivers State?

Table 1: Mean Responses for Ease of Use of Virtual Reality towards Knowledge Gain

S/N	ITEM STATEMENTS	Lecturers (n=52)		
		M	S.D.	RMK
1	I think it will be easy to operate virtual reality.	3.10	0.98	A
2	I think it will be easy for me to use gadgets associated with virtual reality.	3.00	0.97	A
3	I think it will be easy for me to learn to use virtual reality.	3.13	0.95	A
4	I think with the instruction in the user manual, I will be able to use virtual reality.	3.04	0.93	A
5	I think it will not be difficult to understand the operation of virtual reality.	3.08	0.90	A
6	Using virtual reality for instructional purpose will be easy.	2.98	1.04	A
7	The functions in virtual reality are easy to use.	3.13	0.82	A
	Grand Mean	3.07	0.94	A

Source (Field Data; A = Agree)

The result from Table 1 shows that the preservice TVET teacher educators' perception of the usefulness of virtual reality in motivating students for learning in technical education programme in tertiary institutions in Rivers State. The result shows that they had positive perception of Ease of use of virtual reality towards knowledge gain. This is evident by mean responses being greater than 2.50 all the items. Furthermore, grand mean responses of 3.07 confirms that the preservice TVET teacher educators perceived that it will be easy to use for instructional delivery in technical education.

Research Question 2: What are the preservice TVET teacher educators' perception of the usefulness of virtual reality in motivating students for learning in technical education programme in tertiary institutions in Rivers State?

Table 2: Mean Responses for Usefulness of Virtual Reality in Students' Motivation

S/N	ITEM STATEMENTS	Lecturers (n=52)		
		M	S.D.	RMK
1	Virtual reality can boost students' engagement on learning.	3.12	0.92	A

2	Virtual reality could enhance students' participation in learning activity.	3.21	0.87	A
3	Virtual reality could enhance students' attention for learning.	3.00	1.01	A
4	Virtual reality could makes learning more interesting.	3.02	0.98	A
5	I think virtual reality would make learning to be enjoyable.	3.04	0.99	A
6	I think virtual reality would stimulate learning interest among learners.	3.31	0.90	A
7	Virtual reality would be effective in enhancing the attractiveness of instruction in technical education programmes.	3.08	1.03	A
	Grand Mean	3.11	0.96	A

Source (Field Data; A = Agree)

The result from Table 2 shows that the preservice TVET teacher educators' perception of the usefulness of virtual reality in motivating students for learning in technical education programme in tertiary institutions in Rivers State. The result shows that they had positive perception of Ease of use of virtual reality towards knowledge gain. This is evident by mean responses being greater than 2.50 all the items. Furthermore, grand mean responses of 3.11 confirms that they perceived that virtual reality will be useful in motivating students for learning in technical education programme in tertiary institutions in Rivers State.

Research Question 3: What is the preservice TVET teacher educators' perception of the usefulness of virtual reality in helping students gain knowledge in technical education programme in tertiary institutions in Rivers State?

Table 3: Mean Responses for Usefulness of Virtual Reality towards Knowledge Gain

S/N	ITEM STATEMENT	Lecturers (n=52)		
		$\bar{x}$	S.D.	RMK
1	Virtual reality could help to concretize abstract concepts.	3.56	0.50	A
2	Virtual reality could enhance easy understanding of complex topics.	3.48	0.50	A
3	Virtual reality could be a useful tool for teaching concepts not possible in classroom environment.	3.35	0.62	A
4	Virtual reality could be useful for exposing students to practical experience that may be dangerous to conduct in workshops or classroom.	3.40	0.63	A
5	Virtual reality could be a useful tool for enhancing creativity among students.	3.58	0.50	A
6	Virtual reality could be a useful tool for supporting learning by doing.	3.58	0.50	A
7	Virtual reality could enhance easy understanding of complex topics.	3.65	0.48	A
8	Virtual reality could serve as a useful tool for enhancing instructional delivery among teachers.	3.42	0.50	A
9	Virtual reality could be a useful tool for enhancing students' effectiveness in learning.	3.40	0.50	A
10	Virtual reality could serve as a useful tool for boosting academic achievement among students.	3.35	0.62	A
11	Virtual reality could serve as a tool for safely preparing students of technical education for field training.	3.48	0.50	A

12	Virtual reality is a cost effective way of delivering practical training in technical education.	3.25	0.59	A
13	I do not think virtual reality could be useful in teaching and learning of practical activities in technical education.	2.79	1.14	A
14	I do not think virtual reality could enhance learning.	2.48	1.18	D
	Grand Mean	3.34	0.63	A

Source (Field Data; A = Agree)

The result from Table 3 shows that the preservice TVET teacher educators' perception of the usefulness of virtual reality in helping students gain knowledge in technical education programme in tertiary institutions in Rivers State. The result shows that they had positive perception of Ease of use of virtual reality towards knowledge gain. This is evident by mean responses being greater than 2.50 all the items. Furthermore, grand mean responses of 3.34 confirms that they perceived that virtual reality will be usefulness of virtual reality in helping students gain knowledge in technical education programme in tertiary institutions in Rivers State.

Research Question 4: What are the preservice TVET teacher educators' perception of the challenges associated with the use of virtual reality for instructional purpose in technical education programme in tertiary institutions in Rivers State?

Table 4: Mean Responses for Challenges to Using Virtual Reality for Instruction

S/N	ITEM STATEMENT	Lecturers (n=52) $\bar{x}$	S.D.	RMK
1	High cost of facilities needed for implementing virtual reality system could be a challenge to its utilisation in technical education.	3.42	0.50	A
2	Closeness of virtual reality application to modelled scenario could be a potential issue associated with its usage for instruction in technical education.	3.12	0.65	A
3	Concern for health implications of immersive virtual reality is a potential challenge to its usage for instruction in technical education.	3.02	0.58	A
4	Students' perception of the usefulness of virtual reality could be a potential issue to its implementation for instruction in technical education.	3.19	0.69	A
5	Teachers' perception of the usefulness of virtual reality could be a potential issue to its implementation for instruction in technical education.	3.27	0.60	A
6	Students' attitude towards virtual reality could be a potential issue to its implementation for instruction in technical education.	3.42	0.50	A
7	Teachers' attitude towards virtual reality could be a potential issue to its implementation for instruction in technical education.	3.58	0.50	A
8	Adequacy of instructional model underlining a virtual reality system could be a potential issue in its effective use for instruction in technical education.	3.58	0.50	A
	Grand Mean	3.32	0.56	A

Source (Field Data; A = Agree)

Result from Table 4 shows that the lecturers perceive that the listed issues could be challenges to using virtual reality for instructional delivery in technical education. For example, they

generally agreed that teachers' and students' attitude towards virtual reality could be a potential issue in utilizing it for instructional delivery (x =3.42 for lecturers for item 6) and (x =3.58 for item 7). Furthermore, a grand mean response of 3.32 confirms that the respondents agreed that the listed issues could serves as challenges to using virtual reality for instruction al delivery in the study area.

Discussion of Findings

Research question one sought to find out the preservice TVET teacher educators' perception of the ease of use of virtual reality for instructional delivering in technical education programme in tertiary institutions in Rivers State. The result shows that the respondents agreed that: it will be easy to operate virtual reality; it will be easy for me to use gadgets associated with virtual reality; it will be easy for me to learn to use virtual reality; with the instruction in the user manual, using virtual reality will be easy; it will not be difficult to understand the operation of virtual reality; using virtual reality for instructional purpose will be easy; the functions in virtual reality are easy to use. This result is similar to the result obtained by Cooper et al. (2019) who found that participants were interested in VR, they perceived that VR was very engaging and would have positive effect on learning. The result also corroborates the result by Domingo and Bradley (2018) who found that students had positive perception about the usefulness of virtual reality.

Research question two sought to find out the preservice TVET teacher educators' perception of the usefulness of virtual reality in motivating students for learning in technical education programme in tertiary institutions in Rivers State. The result shows that the respondents agreed that: virtual reality can boost students' engagement on learning; Virtual reality could enhance students' participation in learning activity; virtual reality could enhance students' attention for learning; virtual reality could makes learning more interesting; virtual reality would make learning to be enjoyable; virtual reality would stimulate learning interest among learners; virtual reality would be effective in enhancing the attractiveness of instruction in technical education programmes. This result is similar to the result obtained by Lund and Wang (2019) who conducted a study to ascertain the impact of virtual reality on students' motivation to learn as well as its effect on students' academic performance in library and information studies in eastern Kansas, USA. Lund and Wang from their study found that students exposed to instruction through virtual reality had improvement in their level of motivation. Furthermore, the result agrees with that of Antón-Sancho et al. (2024) who found that respondents had positive perception of virtual reality.

Research question three sought to examine the preservice TVET teacher educators' perception of the usefulness of virtual reality in helping students gain knowledge in technical education programme in tertiary institutions in Rivers State. The result showed that the respondents agreed that virtual reality could help to concretize abstract concepts, virtual reality could enhance easy understanding of complex topics, virtual reality could be a useful tool for teaching concepts not possible in classroom environment, virtual reality could be useful for exposing students to practical experience that may be dangerous to conduct in workshops or classroom, virtual reality could be a useful tool for enhancing creativity among students, virtual reality could be a useful tool for supporting learning by doing, virtual reality could enhance easy understanding of complex topics, virtual reality could serve as a useful tool for enhancing instructional delivery among teachers, virtual reality could be a useful tool for enhancing students' effectiveness in learning, virtual reality could serve as a useful tool for boosting academic achievement among students, virtual reality could serve as a tool for safely preparing students of technical education for field training, virtual reality is a cost effective

way of delivering practical training in technical education. They also agreed that virtual reality could be useful in teaching and learning of practical activities in technical education. Furthermore, the preservice TVET teacher educators disagreed to the statement that virtual reality cannot enhance learning in technical education. This is an indication that the respondents had positive perception of the usefulness of virtual reality in helping students gain knowledge in technical education programme in tertiary institutions in Rivers State. This result agrees with the results by Criollo-C et al. (2024), Farsi et al. (2023), Hagge (2020) and Baxter and Hainey (2019). Who similarly found positive perception on utilizing virtual reality for instruction.

Research question four sought to find out the preservice TVET teacher educators' perception of the challenges associated with the use of virtual reality for instructional purpose in technical education programme in tertiary institutions in Rivers State. The result shows that they agreed that high cost of facilities needed for implementing virtual reality system, closeness of virtual reality application to modelled scenario, concern for health implications of immersive virtual reality, students' perception of the usefulness of virtual reality, teachers' perception of the usefulness of virtual reality, students' attitude towards virtual reality, teachers' attitude towards virtual reality and adequacy of instructional model underlining a virtual reality system are potential challenges that could be associated with usefulness and effectiveness of virtual reality in instructional delivery in technical education. This result agrees with the result by Pfeil, Ang and Zaphiris (2009) who conducted a study to ascertain the issues and challenges faced in using virtual reality for educational purposes among students, teachers and institutions. Pfeil, Ang and Zaphiris found challenges associated with using virtual reality to involve technical challenges such as technicality that may be associated with using the tool. The result also agrees with the view of Abdelaziz, Alaa El Din and Senousy (2014) that challenges associated with using virtual reality for teaching and learning include: teaching activity used in the virtual environment (e.g. presentations, tutorials, discussion, field trips, among others).

Conclusions

Based on the findings of this study, it was concluded that the preservice TVET teacher educators had positive perception about the usefulness of virtual reality in instructional delivering in technical education programme. It was also concluded that the preservice TVET teacher educators had positive perception on the usefulness of virtual reality in motivating students for learning in technical education programme. Similarly, the preservice TVET teacher educators had positive perception of the usefulness of virtual reality in helping students gain knowledge in technical education programme. Furthermore, it was concluded that the preservice TVET teacher educators perceived some challenges that could limit effective usage of virtual reality for instructional delivery in technical education programme. Generally, it was concluded that although the preservice TVET teacher educators perceive virtual reality to be a useful instructional tool for technical education programme, there is need for consideration of the potential challenges.

Recommendations

Based on the results and conclusions of this study, the following recommended were made:

1. Considering the usefulness and effectiveness of virtual reality in enabling users have a sense of reality, it should be adopted in the teaching and learning of practical content in technical education.
2. Funds should be provided by Government and supported by non-governmental

agencies to make virtual reality tools available for use in instructional delivery in technical education.

3. Feedbacks should be given to designers and producers of virtual reality on the potential challenges perceived to be associated with using virtual reality for instructional purpose.
4. Such feedback could help in redesigning for enhance usage, especially for instructional purpose in technical education.

REFERENCES

Abdul Hamid, R., Ismail, I. M., & Wan Yahaya, W. A. J. (2024). Augmented reality for skill training from TVET instructors' perspective. *Interactive Learning Environments*, *32*(4), 1291-1299. https://doi.org/10.1080/10494820.2022.2118788

Abich IV, J., Parker, J., Murphy, J. S., & Eudy, M. (2021). A review of the evidence for training effectiveness with virtual reality technology. *Virtual Reality*, *25*(4), 919-933. https://doi.org/10.1007/s10055-020-00498-8

Allcoat, D., Hatchard, T., Azmat, F., Stansfield, K., Watson, D., & von Mühlenen, A. (2021). Education in the digital age: Learning experience in virtual and mixed realities. *Journal of Educational Computing Research*, *59*(5), 795-816.

https://doi.org/10.1177/0735633120985120

Antón-Sancho, Á., Vergara, D., & Fernández-Arias, P. (2024). Quantitative analysis of the use of virtual reality environments among higher education professors. *Smart Learning Environments*, *11*, 13. https://doi.org/10.1186/s40561-024-00299-5

Baxter, G., & Hainey, T. (2019). Student perceptions of virtual reality use in higher education. *Journal of Applied Research in Higher Education*, *12*(3), 413-424. https://doi.org/10.1108/JARHE-06-2018-0106

Bower, M., DeWitt, D., & Lai, J. W. M. (2020). Reasons associated with preservice teachers' intention to use immersive virtual reality in education. *British Journal of Educational Technology*, *51*(6), 2214–2232. https://doi.org/10.1111/bjet.12933

Cooper, G., Park, H., Nasr, Z., Thong, L. P., & Johnson, R. (2019). Using virtual reality in the classroom: preservice teachers' perceptions of its use as a teaching and learning tool. *Educational Media International*, *56*(1), 1-13.

https://doi.org/10.1080/09523987.2019.1583461

Criollo-C, S., Uzcátegui, J. E. C., Guerrero-Arias, A., Yánez, T. A., Samala, A. D., Rawas, S., & Luján-Mora, S. (2024). Use of virtual reality as an educational tool: a comparison between engineering students and teachers. *IEEE Access*, *12*, 86662-86674.

https://doi.org/10.1109/ACCESS.2024.3416673

Domingo, J. R., & Bradley, E. G. (2018). Education student perceptions of virtual reality as a learning tool. *Journal of Educational Technology Systems*, *46*(3), 329-342. https://doi.org/10.1177/0047239517736873

Farsi, G. A., Yusof, A. B. M., Bin Rusli, M. E., & AlSinani, M. (2023). The current perceptions about instructional tools in educational towards adoption of virtual reality among undergraduate students. *International Journal of Interactive Mobile Technologies*, *17*(8), 169-180. https://doi.org/10.3991/ijim.v17i08.36935

Freina, L., & Ott, M. (2015). A literature review on immersive virtual reality in education: State of the art and perspectives. In *The International Scientific Conference eLearning and Software for Education* (Vol. 1, pp. 133–141). https://doi.org/10.12753/2066-026X-15-020

Hagge, P. (2020). Student perceptions of semester-long in-class virtual reality: Effectively using "Google Earth VR" in a higher education classroom. *Journal of Geography in Higher Education*, *45*(3), 342-360. https://doi.org/10.1080/03098265.2020.1827376

Ketoma, V. K., Vanderdonckt, J., & Meixner, G. (2023). Towards flexible authoring and personalization of virtual reality applications for training. *Proceedings of the ACM on Human-Computer Interaction*, *7*(EICS), 1-37. https://doi.org/10.1145/3593241

Lampropoulos, G., & Kinshuk. (2024). Virtual reality and gamification in education: a systematic review. *Educational technology research and development*, *72*(3), 1691-1785. https://doi.org/10.1007/s11423-024-10351-3

Leong, W. Y. (2024, December). Enhancing practical skills training through virtual reality in TVET education. In *2024 International Conference on TVET Excellence & Development (ICTeD)* (pp. 289-293). IEEE. https://doi.org/10.1109/ICTeD62334.2024.10844618

Lund, B. D., & Wang, T. (2019). Effect of virtual reality on learning motivation and academic performance: What value may VR have for library instruction. *Kansas Library Association College and University Libraries Section Proceedings*, *9*(1), 1-9. https://doi.org/10.4148/2160-942X.1073

Makransky, G., Borre- Gude, S., & Mayer, R. E. (2019). Motivational and cognitive benefits of training in immersive virtual reality based on multiple assessments. *Journal of Computer Assisted Learning*, *35*(6), 691-707. https://doi.org/10.1111/jcal.12375

Oyelere, S. S., Bouali, N., Kaliisa, R., Obaido, G., Yunusa, A. A., & Jimoh, E. R. (2020). Exploring the trends of educational virtual reality games: A systematic review of empirical studies. *Smart Learning Environments*, *7*, 1-22. https://doi.org/10.1186/s40561-020- 00142-7

Parong, J., & Mayer, R. E. (2018). Learning science in immersive virtual reality. *Journal of Educational Psychology*, *110*(6), 785-797. https://doi.org/10.1037/edu0000241

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education, 147*, 103778. https://doi.org/10.1016/j.compedu.2019.103778

Rajamanickam, S., Che' Rus, R., & Abdul Raji, M. N. (2024). Enhancing TVET for a digital-ready workforce: A systematic literature review. *International Journal of Modern Education, 6* (23), 865-881. https://doi.org/10.35631/IJMOE.623060

Smutny, P. (2023). Learning with virtual reality: A market analysis of educational and training applications. *Interactive Learning Environments, 31*(10) 6133-6146. https://doi.org/10.1080/10494820.2022.2028856

ASSESSMENT OF BASIC TECHNOLOGY TEACHERS' AWARENESS AND USE OF ARTIFICIAL INTELLIGENCE IN CLASSROOM INSTRUCTION IN SECONDARY SCHOOLS IN MINNA, NIGER STATE

[1]Abdullahi Muhammad Hassan, [2]Roseline Yusuf Karfe, & [3]Chinyere Geraldine Ugwunnagu

[1]Industrial and Technology Education Department,
School of Science and Technology Education,
Federal University of Technology, Minna
[2] Federal University of Health Science
Azare, Bauchi State
Faculty of Basic Science
[3]Woodwork Department, School Of Secondary Education Technical, Federal College Of Education Technical, Isu Ebonyi State

ABSTRACT

This study investigated the awareness and utilization of artificial intelligence (AI) among Basic Technology teachers during classroom instruction in secondary schools across Minna, Niger State. A descriptive survey research design was adopted, utilizing a researcher-structured questionnaire as the primary instrument for data collection. The population comprised 105 Basic Technology teachers drawn from ten randomly selected secondary schools—five each from Bosso and Chanchaga Local Government Areas. The entire population was used as the sample size for the study. The instrument, titled Awareness and Integration of AI by Basic Technology Teachers Questionnaire (AIAIBTTQ), was validated by three subject-matter experts and pilot-tested, yielding a reliability coefficient of 0.77. Data were analyzed using descriptive statistics to address the research questions. Findings revealed that the majority of Basic Technology teachers in Minna demonstrated low awareness of artificial intelligence and rarely integrate AI tools into their instructional practices. Based on these findings, the study recommended the organization of targeted conferences, seminars, workshops, and continuous professional development programs to enhance teachers' awareness and competencies in AI integration. Equipping teachers with such knowledge is vital for leveraging the transformative potential of AI and other digital technologies in the classroom.

Keyword: Artificial Intelligence (AI), Basic Technology Teachers, Classroom Instruction, Teacher Awareness, AI Integration, Digital Pedagogy, Secondary Education, Minna, Niger State, Descriptive Survey, Teacher Professional Development

Introduction

The exponential growth of digital technology continues to reshape every facet of human endeavour, and education is no exception. Among the most transformative of these technologies is Artificial Intelligence (AI), which is now making significant inroads into

teaching and learning processes globally. AI-powered applications such as adaptive learning platforms, intelligent tutoring systems, and automated feedback tools have the potential to revolutionize instructional delivery by promoting personalized learning and improving students' academic outcomes (Holmes, Bialik, & Fadel, 2019). In developed countries, the integration of AI into classrooms has begun to yield positive outcomes; however, in many developing countries like Nigeria, awareness and utilization remain relatively low (Afolabi, 2021).

Artificial Intelligence (AI) has been defined in many ways by many experts. For instance, Adebayo *et al* (2021) refers to AI as the simulation of human intelligence processes by machines, particularly computer systems. This implies that, AI has the capability of enabling machines to execute tasks that supposedly or typically require human intelligence if effectively incorporated by teachers (Fahimirad, and Kotamjani, 2018). Some of the tasks can be executed by machine through the use of AI include visual perception, speech recognition, decision-making, language translation to mention a few. To a large extent, AI is believed to be capable of imitating (mimic) human cognitive functions such as learning, problem-solving, simplifying complex data and providing solution to complex tasks during classroom instruction. In addition, Mikalef and Gupta (2021) opined that AI is helpful in enhancing teachers' instructional strategies, preparing students for better performance at any standardized examinations as well as providing the nation with a very sound technology-driven future. This is expected to be able to bring about national peace, unity, stability, growth and development.

Basic Technology is a core subject in Nigerian junior secondary schools designed to foster foundational scientific and technological literacy among learners. As a gateway to science, engineering, and vocational training, the delivery of this subject must be aligned with modern educational innovations, including AI tools (Yusuf & Adedokun, 2022). Teachers, who are central to the effective transmission of knowledge and skills, must therefore be adequately informed and equipped to adopt emerging technologies in their instructional practice. Without sufficient awareness and capacity to apply AI, educators risk falling behind in delivering 21st-century learning (UNESCO, 2021).

Despite the increasing global emphasis on AI in education, many Nigerian teachers remain unaware of its implications and applications. Factors such as limited professional training, lack of access to digital tools, inadequate infrastructure, and poor policy implementation have been identified as barriers to effective technology integration (Okebukola, 2020; Olumorin *et al.,* 2021). Furthermore, the success of educational technologies, including AI, largely depends on teachers' attitudes, competencies, and the institutional support they receive (Ifinedo, 2017).

This study focuses on Minna metropolis, the capital of Niger State, with emphasis on Basic Technology teachers in Bosso and Chanchaga Local Government Areas. It seeks to assess the extent of their awareness of artificial intelligence and how frequently they integrate it in classroom instruction. Understanding the current state of AI awareness and usage among these educators is crucial for informed policy direction, targeted teacher training, and the broader digital transformation of Nigeria's secondary education system.

Statement of the Research Problem

Classroom instruction is expected to take place in such a way that both teachers and students would be comfortable and convenient for educational objective of teachers' maximum productivity and students' better performance to be achieved. This implies that teachers must possess the prerequisite qualification and use the related and relevant instructional strategies for students to have a maximum comprehension of what they are taught in order to obtain

better results at any standardized examination. Students' better performance at any standardized examination would therefore be used as a yardstick to judge whether effective teaching and meaningful learning has taken place or not (Lamb and Fullarton, 2019).

Unfortunately, research findings have revealed that standard of education has fallen as the students' performance continued to decline (Fauth *et al.,* 2019: Abdullahi *et al.,* 2021 and WAEC, 2021). This necessitated the need to have a look at factors responsible for such persistent decline. Among the factors identified to be responsible are teachers' factors especially the teachers' instructional strategies (Popenici and Kerr. 2017). The search for effective instructional strategies brought about the integration of technology in classroom instruction. Over the years, integration of technology in classroom instruction has been the focus of all the stakeholders in education. To this effect, integration of technology with Artificial Intelligence (AI) has become one of the new and current trends in classroom instruction globally. The use of AI in classroom instruction underscores the differences between the potential benefits of integrating AI into classroom instruction and the actual utilization of AI tools among secondary school teachers. This is because some secondary school teachers' literacy level with respect to the use of AI in classroom is very low (Bharati, 2017). In specific terms, some secondary school teachers' knowledge that application capability of integration of AI during classroom instruction is very low. This is one of the reasons that motivated the researchers to conduct this study. The study is therefore aimed at focusing on the gap between Basic technology teachers' level of awareness and integration of AI during classroom instruction. It is therefore hoped that, findings of this study would help in bridging the gulf between Basic technology teachers' level of awareness and integration of AI during classrooms. Findings would also help in providing the needed training to the teachers so as to enable them effectively utilize AI during classroom instruction. It is on the basis of the foregoing that this study was designed to determine the Level of Awareness and Integration of Artificial Intelligence (AI) during classroom Instruction among Secondary School Basic technology teachers in Minna, Niger State.

Aim and Objectives

The aim of this study was to determine the assessment of basic technology teachers' awareness and use of artificial intelligence in classroom instruction in secondary schools in minna, Niger State. Specifically, the research objectives include accessing the:

1. level of awareness of Artificial Intelligence (AI) for classroom instruction among Basic technology teachers in Minna, Niger State
2. frequency of Integration of Artificial Intelligence (AI) during classroom instruction by Basic technology teachers in Minna, Niger State

Research Questions

The following corresponding research questions were raised to guide the study.

1. What is the level of awareness of Artificial Intelligence (AI) for classroom instruction among Basic technology teachers in Minna, Niger State?
2. How frequent is Artificial Intelligence (AI) being integrated during classroom instruction by Basic technology teachers in Minna, Niger State?
3. It is hoped that, findings of this study would be of benefit to students, teachers, curriculum planners, examination bodies and government.

Methodology

Research design used for this study is survey research design (descriptive survey research design). This design was used for the study because it enables researchers to select a sample from a large population and use as representative of the larger population. Population of the study consists of all the secondary school Basic technology teachers in Minna, Niger State. During sample and sampling techniques, a multi-stage sampling technique was used. The first

stage was concerned with identifying and grouping of all the secondary schools in Minna into two based on the basis of the Local Government Areas (LGA) the schools are located. This means that the schools were grouped as schools in Bosso Local Government Area and schools in Chanchaga Local Government Area. The second stage involved the use of simple random sampling technique by balloting to select five secondary schools from each of the two LGA making a total of ten secondary schools used for the study. The third stage involved use of purposive sampling technique to select only the Basic technology teachers from the ten sampled schools and used for the study. All the Basic technology teachers in the ten selected schools were used for the study. This gave a total of one hundred and five (105) Basic technology teachers which formed the sample size of the study.

Research Instrument

The researchers employed the use of questionnaire to collect data from the secondary school Basic technology teachers (respondents). The questionnaire was designed by the researchers and titled "Secondary School Basic technology teachers' Awareness and Integration of Artificial Intelligence Questionnaire'. The questionnaire consists of three sections (A, B and C). Section A is about the demographic information of the Basic technology teachers. Section B consists of items on Basic technology teachers' level of awareness of Artificial Intelligence (AI) in teaching. Section C on the other hand, consists of items on Basic technology teachers' frequency of integration of Artificial Intelligence during teaching.

Section B was structured using 5-Point Likert scale of Extremely Aware (EA) = 5, Moderately Aware (MA) = 4, Somewhat Aware (SWA) = 3, Slightly Aware (SA) = 2 and Not at All Aware (NAA) = 1. Section C was also structured using 5-Point Likert scale of AI (Always Integrate) = 5, OI (Often Integrate) = 4, ST (Some Times Integrate) = 3, R (Rarely Integrate) = 2 and N (Never Integrate) = 1. The decision mean of the instrument was calculated to 3 (5+4+3+2+1 = 15/5 = 3). This implies that any mean score that is less than 3.00 is rejected while mean score from 3.00 and above is accepted.

Validity and Reliability of the Instrument

The instrument was validated by three experts. One expert from the Department of Science Education and one expert from the Department of Educational Technology both from Federal University of Technology, Minna validated the instrument. Another one expert from Test and Measurement unit of Niger State Ministry of Education, Minna also validated the instrument. The experts studied, rearranged and satisfied the items on the instrument to be relevant and adequate. However, some items were dropped and some new ones were added to the initial items submitted by the researchers for validation. Suggestions, observations and corrections from the experts were used to produce the final copy of the instrument used for the study. Thereafter, the instrument was pilot tested using Basic technology teachers from Government Day Secondary School in Minna which was not part of the schools used for the study to determine the reliability coefficient of the instrument. Split half method was used after administering the questionnaires to the Basic technology teachers. Data collected was analyzed using SPSS version 23 and Cronbach Alpha the statistical tool used. For items on the awareness of AI by Basic technology teachers, a reliability coefficient of 0.75 was obtained while 0.78 was obtained for the items on frequency of Integration of AI by Basic technology teachers. The average reliability coefficient was determined to be 0.77 indicating that the instrument is reliable and can be used for the study.

During data collection, the researchers visited all the sampled school to seek permission from the school authorities to use the schools for research study. After permission was granted and the researchers introduced to the Basic technology teachers, research assistants were appointed and trained by the researchers for the purpose of the study from each of the sampled schools. The researchers with the help of the research assistants administered the

questionnaires to the sampled Basic technology teachers used for the study. The respondents were given enough time to read the instructions and respond to the questionnaire. Thereafter, the researchers with the help of research assistants collected the answered questionnaires from respondents. Data collected was later analyzed using Statistical Package for Social Sciences (SPSS). Mean and Standard deviation was used to answer research questions as presented under results and discussion.

Results and Discussion

Research Question One: What is the level of awareness of Artificial Intelligence (AI) for classroom instruction among Basic technology teachers in Minna, Niger State? To answer this research question, mean and standard deviation were used as presented in Table 1.

Table 1: Basic technology teachers' Level of Awareness of the AI for Classroom Instruction

S/N	AI (ITEMS)	N	MEAN	SD	DECISION
1	Alexa	105	2.80	1.07	Not Aware
2	Astro	105	2.07	0.50	Not Aware
3	Ada Healthcare App	105	3.78	1.74	Aware
4	Brain.FM	105	2.95	1.O2	Not Aware
5	Capsule AI	105	2.70	1.06	Not Aware
6	Cortana	105	2.02	0.30	Not Aware
7	Duolingo Bots	105	2.97	1.03	Not Aware
8	Elsa Speak	105	3.10	1.07	Aware
9	FaceApp	105	3.02	1.02	Aware
10	Google Assistance	105	2.40	0.90	Not Aware
11	Hound	105	3.20	1.04	Aware
12	Lisa	105	3.30	1.04	Aware
13	Oliva	105	2.60	1.05	Not Aware
14	Parla	105	3.04	1.10	Aware
15	Replica	105	2.56	1.04	Not Aware
16	Siri	105	3.40	1.06	Aware
17	Socratic	105	3.00	1.05	Aware
18	Tetra	105	2.40	1.01	Not Aware
19	Trove	105	2.95	1.04	Not Aware
20	Wysa	105	2.71	1.18	Not Aware
Cumulative Total			**2.85**	**1.02**	**Not Aware**

Table 1 reveals the level of awareness of Artificial Intelligence (AI) for classroom instruction among Basic technology teachers in Minna, Niger State. The result shows that, higher parts of the Basic technology teachers that responded are skewed towards the "Not Aware" response. This is because the cumulative mean of 2.85 with standard deviation of 1.02 is less than the decision mean of 3.00. This therefore, implies that the majority of the Secondary School Basic technology teachers in Minna, Niger State are not aware of the use of Artificial intelligence (AI) for classroom instruction.

Research Question Two: How frequent is Artificial Intelligence (AI) being integrated during classroom instruction by Basic technology teachers in Minna, Niger State? To answer this research question, mean and standard deviation were used as presented in Table 2.

Table 2: Basic technology teachers' Frequency of Integration Artificial Intelligence (AI) during Classroom Instruction

S/N	AI (ITEMS)	N	MEAN	SD	DECISION
1	Alexa	105	1.30	0.07	Not Frequent
2	Astro	105	2.07	1.50	Not Frequent
3	Ada Healthcare App	105	2.78	0.74	Not Frequent
4	Brain.FM	105	2.95	1.O2	Not Frequent
5	Capsule AI	105	2.70	1.02	Not Frequent
6	Cortana	105	2.02	0.30	Not Frequent
7	Duolingo Bots	105	2.47	1.01	Not Frequent
8	Elsa Speak	105	3.14	1.08	Frequent
9	FaceApp	105	3.01	1.04	Frequent
10	Google Assistance	105	2.80	1.04	Not Frequent
11	Hound	105	2.20	0.60	Not Frequent
12	Lisa	105	2.60	1.01	Not Frequent
13	Oliva	105	2.80	1.04	Not Frequent
14	Parla	105	2.04	1.01	Not Frequent
15	Replica	105	2.06	1.02	Not Frequent
16	Siri	105	3.01	1.04	Frequent
17	Socratic	105	2.00	0.95	Not Frequent
18	Tetra	105	2.40	0.98	Not Frequent
19	Trove	105	2.79	1.04	Not Frequent
20	Wysa	105	2.23	0.07	Not Frequent
Cumulative Total			**2.50**	**0.88**	**Not Frequent**

Table 2 reveals the frequency of integration of Artificial Intelligence (AI) during classroom instruction among Basic technology teachers in Minna, Niger State. The result shows that, a large number of the Basic technology teachers that responded are skewed towards the 'Not Frequent' response. This is because, the cumulative mean of 2.50 with standard deviation of 0.88 is lower than the decision mean of 3.00. This therefore, implies that a large number of the Secondary School Basic technology teachers in Minna, Niger State do not frequently integrate Artificial intelligence (AI) during classroom instruction.

Discussion of Findings

Research question one that, majority of the Secondary School Basic technology teachers in Minna, Niger State are not aware of the use of Artificial intelligence (AI) for classroom instruction. This finding is in line with the findings of Adebayo *et al* (2021) who conducted a research study on University Students' Awareness of, Access to, and use of Artificial Intelligence for Learning in Kwara State. It was reported that majority of the university students are not skilled as well as competent in the use of AI for learning which implies that they lack awareness and access to AI.

Research question two revealed that, a large number of the Secondary School Basic technology teachers in Minna, Niger State do not frequently integrate Artificial intelligence (AI) during classroom instruction. This finding is also in consonance with the findings of Ahmet *et al* (2024) who investigated the level of awareness among teachers regarding the use of artificial intelligence (AI) in education and reported that the group of teachers that uses AI during classroom instruction is the secondary school teachers. In addition, the finding is also in line with findings of Ikedinachi *et al* (2019) who reported that the use of AI is capital

intensive because it is largely technologically dependent as such; it is not always integrated by majority of teachers.

Conclusion

From the findings of the study, it is concluded that, majority of the Secondary School Basic technology teachers in Minna, Niger State are not aware of the use of Artificial Intelligence (AI) for classroom instruction and are not frequently integrating it during classroom.

Recommendations

Based on the findings of the study, it is recommended that conferences, seminars, workshops as well as training and retraining programs be organized for the Basic technology teachers on awareness and integration of Artificial Intelligence during classroom instruction. This will help in giving the Basic technology teachers the ability to effectively explore the use of Artificial Intelligence and other digital resources during classroom instruction.

REFERENCES

Abdullahi, A., Rabiu, M. B. & Koroka, M. U. S. (2021). Impact of Out-of-Field Secondary School Basic technology teachers'g37 Content Mastery and Classroom Management Anxiety on Pedagogical Content Knowledge in Niger State, Nigeria. Unpublished PhD Thesis, Federal University of Technology, Minna, Niger State.

Adebayo, E, A,, Oseun. F, B,. Gboyega, A. A. & Ebenezer, O, B, (2021). University Students' Awareness of, Access to, and use of Artificial Intelligence for Learning in Kwara State. *Indonesian Journal of Teaching in Science* 1(2), 91-104

Ahmet, G. 1., Nazım, S. B., Sonay, D., Nazan, C., Sinem, B., Şeyma, E. Ş. & Hüseyin, G. (2024). Exploring Teacher Awareness of Artificial Intelligence in Education: A Case Study from Northern Cyprus. Journals EJIHPE (14) 10.3390/ejihpe14080156

Bharati, K. F. (2017). A survey on artificial intelligence and its applications. *International Journal of Innovative Research in Computer and Communication Engineering,* 5(60), 11614-11619.

Fahimirad, M., and Kotamjani, S. S. (2018). A review on application of artificial Intelligence in Teaching and Learning in Educational Contexts. International Journal of Learning and Development, 8(4), 106-118.

Fauth, B., Decristan, J., Decker, A. T., Büttner, G., Hardy, I., Klieme, E., & Kunter, M. (2019). The effects of teacher competence on student outcomes in elementary science education: The mediating role of teaching quality. *Teaching and Teacher Education, 86*, 102882.

Ikedinachi, A. P., Misra, S., Assibong, P. A., Olu-Owolabi, E. F., Maskeliūnas, R., and Damasevicius, R. (2019). Artificial Intelligence, Smart Classrooms and Online Education in the 21st Century: Implications for Human Development. Journal of Cases on Information Technology (JCIT), 21(3), 66-79.

Lamb, S.; Fullarton, S. (2019). Classroom and School Factors anecting Mathematics Achievement: A ComparativeStudy of the US and Australia Using TIMSS. 2001. Available online: http://research.acer.edu.au/timss_monographs/10 (accessed on 6 June 2020)

Meyer, M. W., and Norman, D. (2020). Changing design education for the 21st Century. She Ji: The Journal of Design, Economics, and Innovation, 6(1), 13-49.

Mikalef, P., and Gupta, M. (2021). Artificial Intelligence Capability: Conceptualization, Measurement Calibration, and Empirical Study on its Impact on Organizational Creativity and Firm Performance. Information and Management, 58(3), 103434.

Musa,A.A., Ismaila,T.S., Owolabi,P.A., Kehinde,D.A. & Solomon, S. O. (2022). Teachers' Readiness and Intention to Teach Artificial Intelligence in Schools. Computers and

Education: Artificial Intelligence. Volume 3.https://doi.org/10.1016/j.caeai.2022.100099

Olaiya, W. A., Hassan, A. A. & Gana, C. S. (2019). Physics Teachers' Content and Pedagogical knowledge as Correlates of Physics Achievement of Senior Secondary School Students in Borgu, Niger State. Unpublished MTech Thesis, Federal University of Technology, Minna, Niger State

Popenici, S. A., and Kerr, S. (2017). Exploring the impact of artificial intelligence on Teaching and learning in Higher Education. Research and Practice in Technology Enhanced Learning, 12(1), 1-13.

WAEC, (2021). The West African Examinations Council Chief Examiners' Report

EVALUATION OF TEACHERS' IMPLEMENTATION STRATEGIES OF THE BASIC SCIENCE AND TECHNOLOGY CURRICULUM IN JUNIOR SECONDARY SCHOOLS IN NIGER STATE

[1]Salihu Danladi Alhaji, [2]Usman Ibrahim Adamu and [3]Ibrahim Ya'u
Aliko Dangote University of Science and Technology, Wudil
+2348063207557

Abstract
This research work assessed the Basic Science and Technology curriculum implementation in Junior Secondary Schools in Niger State, Nigeria. The study was conducted using four objectives which were translated in to research questions. Descriptive survey design was adopted with 99 population with sample size of 60, which were randomly selected across the 30 junior secondary in Bosso and Chanchanga Local Government Area. The instruments used for data collection were questionnaire titled Assessment of Basic Science and Technology Curriculum Implementation Questionnaire. Mean, Standard Deviation and frequency and percentage were used for descriptive analysis. The research findings from this analysis reveals that: the Basic Science and Technology curriculum content is not being properly implemented; most of the Basic Science and Technology institutional material are not available and the few that are available are not adequate. Based on these findings five recommendations were proffered which include; all people concerned with the implementation of Basic Science and Technology curriculum content should be actively involved and committed to ensure the effective implementation of Basic Science and Technology curriculum in Nigeria, Basic Science and Technology teachers need to be conversant with the appropriate and newly discovered teaching methods and strategies and as well employ them while teaching Basic Science and Technology, Basic Science and Technology instructional materials and resources should be made available to the schools, there is need to consider teacher motivation, and provide adequate classrooms for Basic Science and Technology lessons and Quality assurance officials should put more effort and perform their duties accordingly.
KEYWORDS: Evaluation, teachers' implementation, strategies, basic science and technology, curriculum

Introduction
Basic Science and Technology is one of the subjects offered at junior secondary school level of Nigeria education. The subject was structured to assist learners to develop interest in science and technology. The aim is that by the end of the junior secondary school, presently known as basic 9, science and technological appreciation would have been activated and sustained, and foundation laid for students' entrance into science and technology courses at senior secondary level of education as stated in the National Curriculum for Junior Secondary Schools (2018). Furthermore, the national curriculum maintains that, the subject of Basic Science and Technology which was then Basic Technology is to be offered in junior secondary schools so as to reduce widespread ignorance about science and technology, lay a firm foundation for national development and inspire an increase in skill acquisition. Basic Science and Technology is a subject that introduces students at the junior secondary level of education in Nigeria, to the fundamental tips in technology.

In the light of the feedback on the implementation of the 9-Year basic education curriculum (BEC) received and the contemporary global and national concerns, the Nigerian government revised the 9- Year BEC in 2022 in line with global best practices as in Kenya -7 subject, Tanzania- 8 subject, United States of America -6 subject, Malaysia and Indonesia -9 subject offerings (Obioma, 2022). The curriculum revision process involved identification and

grouping of related disciplines such as Basic science, Basic Technology, Physical and Health Education and Information Technology to create a new composite or cluster of Revised BEC subject called Basic Science and Technology . Key concepts in the former curricula now form integrating threads for organizing the contents of the new subject into a coherent whole.

The new BEC was developed in response to Nigeria's need for relevant, dynamic and globally competitive education that would ensure that learners at the Basic Education level are capable to compete favourably anywhere in the world in terms of knowledge, skills, techniques, values and aptitude. Thus the new 9-Year BEC addressed among other things, the issue of value re-orientation, poverty eradication, critical thinking, entrepreneurship and life skills. Implementation of the new 9-Year BEC commenced nationwide, in Primary 1 and JSS 1 classes in September, 2018, while the old curriculum (the 6-3-3-4 Curriculum) was systematically being phased out. The first batch of JSS students graduated in June, 2021 after writing the Basic Education Certificate Examination (BECE). By September, 2024, the cohort of pupils that benefited from the use of BEC at the primary school level entered class one of the Junior Secondary School.

The framework of the New Basic Education Curriculum reflects the following:

i. The curriculum is designed to properly target pupils and students needs and interests to make provision for appropriate core and elective subjects for a well-rounded education at the different age levels
ii. The lower and Middle Basic Education Curricula (for primary 1-6) will be in full use by the year 2024 and the Upper Basic Education Curriculum (for JS 1-3) will be achieved by the year 2021
iii. Every child is expected to complete primary 6 before being placed in Junior Secondary (JS1)

The National Policy on Education (NPE: 2024) defines Science and Technology as a topic that encompasses science, technology, and the interactions between the two. Science is a systematic enterprise that builds and organizes knowledge in the form of explanations and predictions about nature and the universe. Technology is the collection of techniques, methods or processes used in the production of goods or services or in the accomplishment of objectives, such as scientific investigation, or any other consumer demands.

The development of science and technology is also recognized worldwide as vital for a nations overall economic development. When used effectively science and technology is able to improve productivity and meet the needs of society. This has been demonstrated in the developed nations, and more recently in the newly industrialising nations, where science and technology have been responsible for more than half of the increase in productivity. The quest for technological advancement and industrial revolution therefore demands for a robust and inclusive science and technology curriculum at basic level of education. The curriculum should appeal to all learners and relevant to their need, regardless of backgrounds. Pupils are likely to learn better when they are interested in the subject and the subject is also relevant to their need, hence it becomes important to prepare curriculum that will be relevant and adequately cater for the need and interest of the pupils. There is evidence that using relevant context leads to a better understanding of the concepts involved compared to traditional teaching (Ramsden, 2017, Osborne & Collins, 2021) but a curriculum that uses content that is relevant and related to familiar and interesting phenomena and experiences in the local environment of the pupils may lead to a more meaningful learning (Nganunu, 2018).

In order to reduce ignorance in relation to science and technology and help lay a solid foundation for true national development, Basic Science and Technology has been accorded a place in the school curriculum as a core subject like English and Mathematics.

Damole (2021) stated that in the Nigerian education continuum, basic education as the foundation requires a sound knowledge of science and technology. This is not only because science and technology has a tremendous impact on all social institutions but because science teaching is "somewhat on the downside. The 9 years Basic Science and Technology Curriculum is therefore a restructuring and re-engineering of the revised core curriculum for Primary science and integrated science of Junior Secondary school currently in use.

In the selection of content for the new Basic Technology curriculum, Globalization, Information and communication Technology (ICT) and Entrepreneurship were the three major issues considered to be crucial in the development of a child, important to the nation, and influencing the contemporary world of knowledge. Thus in the aspiration for identification with contemporary development globally, it has become inevitable for Nigeria to incorporate relevant content into the school curriculum.

The new Basic Science and Technology (BST) curriculum now comprised of four subjects-basic science, basic technology, physical and health education and information technology. The objectives of the present BST curriculum are to reduce subjects overload and content repetition at Junior Secondary School (JSS) and also to adequately prepare students at JSS for SSS learnings and activities in science and technology subjects (Federal Ministry of Education, 2017). It is expected that this new curriculum will now serve as a preparatory (prerequisite) subject for science and technology subjects such as Physics, Chemistry, Biology, Agricultural Science, Health Education, computer related subjects, Technical Drawing, Basic Electronic, Metal Work,. Wood Work. Auto-Mechanic at SSS level. However, there are has been a lot of criticism on the effectiveness of the present basic education curriculum of which BST curriculum is included (Nwaubani &Azuh, 2024). Hence the need to assess the implementation of the new Basic Science and Technology curriculum to determine whether it is achieving the objective of introducing it.

Statement of the Problem

Basic Science and Technology in the junior secondary schools in Nigeria, is yet to reach its full potentials and engender full knowledge and vocational competences among Nigerian youths. This is because Basic Science and technology is confronted by myriads of problems such as which militate against its proper and efferent teaching in junior secondary schools. This study therefore sought to assess the extent to which basic science and technology curriculum is being implement in Nigeria secondary school and the problems inherent in the implementation of the already reformed curriculum.

Aim and Objectives of the Study

The aim of the study is to assess the extent to which basic science and technology curriculum content is being implemented in Nigeria Junior Secondary Schools.

The specific objectives are to;

1. Ascertain the teaching methods used by basic science and technology teachers in the implementation of the basic science and technology curriculum in Nigeria Junior Secondary Schools.
2. Identify the available instructional materials used in the implementation of basic science and technology curriculum in Nigeria Junior Secondary Schools.
3. Determine the adequacy of the available instructional material used in the implementation of the curriculum.
4. Identify the problems associated with the implementation of the basic science and technology curriculum in Nigeria Junior Secondary Schools.

Research Questions

The following are the guided research questions:

1. What are the teaching methods used by science and technology teachers in implementing Basic Science and Technology curriculum at Junior Secondary Schools?
2. What are the available instruction materials used for implementing Basic Science and Technology in Nigeria Junior Secondary Schools?
3. How adequate are the available instructional materials used for implementing Basic Science and Technology curriculum?
4. What are the problems associated with the implementation of the basic science and technology curriculum in Nigeria Secondary Schools?

Methodology

The descriptive survey design was adopted for the study. The research comprised of Basic Science and Technology teachers and principals in Bosso and Chanchanga local government area of Niger state. The sample size used for the conduct of this study was 60 respondents, 15 principals and 15 Basic Science and Technology teachers from each local government area used for the study. A random sampling technique was used in the study. Assessment of Basic Science and Technology Curriculum Implementation Questionnaire was used for data collection. The questionnaire was divided into two sections, sections A and B. Question in section A dwells on the bio-data of respondent and a guide on how to respond to the questionnaire items. While Section B consist of 33 items raised in the four research questions. The questionnaire (Assessment of Basic Science and Technology Curriculum Implementation Questionnaire) used by researcher was validated by 3 lecturer in the Department of Industrial and Technology Education Federal University of Technology Minna for appropriate correction in order to produce the relevant information needed for answering the research questions. The validated questionnaire was used to collect data for this study. Cronbach's alpha reliability method was used to determine the internal consistency of the instrument for the data collection. The researcher pay a visit to the schools concerned. The respondents are: Basic Science and Technology teachers and principals. The questionnaire administered to teachers and principals were duly returned, presenting 100% return rate. The data used for this study were analysis by using frequency count, statistical mean score method and Standard Deviation to agree or disagree on the respondents opinion on a particular item contained in the instrument. The mean score of each item was computed by multiplying the frequency of each response mode with appropriate nominal value and divided by the sum obtained under each item with the number of the respondents to an item.

Results

The following descriptive statistics were presented to answer the research questions:

Research Question 1

What are the teaching methods used by science and technology teachers in implementing Basic Science and Technology curriculum at Junior Secondary Schools?

Table 1: The mean and standard deviation scores for the teaching methods used by by science and technology teachers in implementing Basic Science and Technology curriculum at Junior Secondary Schools.

S/N	Item	Mean	Standard Deviation	Remarks
1	Basic Science and Technology teachers often used cognitive development methods of teaching such as Discussion Method, Questioning/Socratic Method, Team Teaching Method, Talk Chalk/Recitation Method, Field Trip/Excursion Method and Team Teaching Method	3.20	.410	Agree
2	Basic Science and Technology teachers often used Affective Development Method of teaching such as Modelling Method, Simulation Method, Dramatic Method, Simulation Games and Role-Playing Method	3.15	.489	Agree
S/N	**Item**	**Mean**	**Standard Deviation**	**Remarks**
3	Basic Science and Technology teachers often used Psychomotor Development Methods of teaching such as Inquiry Method, Discovery Method, Process Approach Method, Demonstration Method, Laboratory/Experimentation Method, Programmed Learning Method, Dalton Plan/Assignment Method and Project Method	3.10	.718	Agree
4	Basic Science and Technology teachers used traditional method of teaching such as lecturing, dictation, drill, teacher led discussion and explanation.	3.20	.616	Agree
5	Basic Science and Technology teachers used modern method of teaching such as problem – based learning, didactic games methods, brainstorming, heuristic method	3.25	.550	Agree

The data presented in Table 1 revealed that the respondents agreed with all the items with the mean score ranges 3.10 to 3.25. This showed that the mean value of each item was above the cut-off point of 2.50, indicating that all Basic Science and Technology teachers often use cognitive developments method, affective development method, psychomotor development method, traditional method and modern method of teaching.

Research Question 2

What are the available instruction materials used for implementing Basic Science and Technology in Nigeria Junior Secondary Schools?

Table 2

Frequency and percentage of the available instruction materials used for implementing Basic Science and Technology in Nigeria secondary school.

S/N	ITEMS	FREQUENCY		PERCENTAGE (%)	
		Available	**Not Available**	**Available**	**Not Available**
1	Textbooks	60	0	100.00	0.00
2	Charts	44	16	73.33	26.67
3	Flat Pictures	38	22	63.33	36.67

4	Posters	45	15	75.00	25.00
5	Cartoon	12	48	20.00	80.00
6	Real Objects	47	13	78.33	21.67
7	Mock-up	0	60	0.00	100.00
8	Science and Technology Resource Centre	0	60	0.00	100.00
9	Chalkboard/Whiteboard	60	0	100.00	0.00
10	Flannel Board	3	57	5.00	95.00
11	Multimedia Projector	4	56	6.67	93.33
12	Computer Assisted Instruction	4	56	6.67	93.33
13	Internet	4	56	6.67	93.33

The data presented in Table 2 shows that Textbooks, Charts, Flat-pictures, Posters, Real-Objects and Chalkboard/Whiteboard are available for implementing Basic Science and Technology in Nigeria secondary school.

Research Question 3

How adequate are the available instructional materials used for implementing Basic Science and Technology curriculum?

Table 3

Frequency and percentage of the adequacy of the available instruction materials used for implementing Basic Science and Technology in Nigeria secondary school.

S/N	ITEMS	FREQUENCY		PERCENTAGE (%)	
		Adequate	Not Adequate	Adequate	Not Adequate
1	Textbooks	55	5	91.67	8.33
2	Charts	26	34	43.33	56.67
3	Flat Pictures	0	60	0.00	100.00
4	Posters	18	42	30.00	70.00
5	Cartoon	1	59	1.67	
6	Real Objects	12	48	20.00	80.00
7	Mock-up	0	60	0.00	100.00
8	Science and Technology Resource Centre	0	60	0.00	100.00
9	Chalkboard/Whiteboard	60	0	100.00	0.00
10	Flannel Board	0	60	0.00	100.00
11	Multimedia Projector	0	60	0.00	100.00
12	Computer Assisted Instruction	0	60	0.00	100.00
13	Internet	0	60	0.00	100.00

The data presented in Table 3 shows that only Textbooks and Chalkboard/Whiteboards are adequately available for implementing Basic Science and Technology curriculum.

Research Question 4

What are the problems associated with the implementation of the basic science and technology curriculum in Nigeria Secondary Schools?

Table 4

The mean and standard deviation scores for the problems associated with the implementation of the Basic Science and Technology curriculum in Nigeria Secondary Schools.

S/N	Items	Mean	Standard Deviation	Remarks
1	There are no adequate instructional materials for proper implementation of Basic Science and Technology curriculum in my school.	2.90	.968	Agree
2	There is no teacher motivation in my school.	2.85	.671	Agree
3	There are no adequate classrooms for Basic Science and Technology lessons in my school.	2.60	.883	Agree
4	There are no adequate and up to-date Basic Science and Technology textbooks in my school.	1.95	.826	Disagree
5	There are no adequate funding for proper implementation of Basic Science and Technology curriculum.	3.10	.788	Agree
6	There are no adequate workshops and laboratories for Basic Science and Technology lessons in my school.	3.15	.587	Agree
7	Lack of technology tools and equipment affect the implementation of Basic Science and Technology curriculum .	3.25	.786	Agree
8	Insufficient power supply makes the operating of available Basic Science and Technology equipment difficult	3.25	.639	Agree
9	The use of resource person is not always considered in the implementation of Basic Science and Technology in junior secondary schools.	3.15	.587	Agree
10	Most of junior secondary school students are not interested in Basic Science and Technology lesson.	1.90	.641	Disagree
11	There are no qualified Basic Science and Technology teachers in my school.	1.50	.761	Disagree
S/N	**Items**	**Mean**	**Standard Deviation**	**Remarks**
12	Our community members have negative attitudes towards Basic Science and Technology education which also affect the implementation of Basic Science and Technology curriculum at Junior Secondary School	2.10	.447	Disagree
13	Basic Science and Technology teachers develop apathy to workshop practice due to lack of motivation.	2.50	.607	Agree

The data presented in Table 4 shows that up to-date Basic Science and Technology textbooks, students interest in Basic Science and Technology lesson, Basic Science and Technology teachers qualification, community members attitudes towards Basic Science and Technology education are not problems associated with the implementation of the basic science and technology curriculum in Nigeria Secondary Schools.

Summary of Major Findings

The following major findings were discovered in this research:

1. Basic Science and Technology teachers often used cognitive development methods of teaching such as Discussion Method, Questioning/Socratic Method, Team Teaching Method, Talk Chalk/Recitation Method, Field Trip/Excursion Method and Team Teaching Method, Affective Development Method of teaching such as Modelling Method, Simulation Method, Dramatic Method, Simulation Games and Role-Playing Method, Psychomotor Development Methods of teaching such as Inquiry Method, Discovery Method, Process Approach Method, Demonstration Method, Laboratory/Experimentation Method, Programmed Learning Method, Dalton Plan/Assignment Method and Project Method, traditional method of teaching such as lecturing, dictation, drill, teacher led discussion and explanation and modern method of teaching such as problem – based learning, didactic games methods, brainstorming, heuristic method in the implementation of Basic Science and Technology curriculum.
2. Textbooks, Charts, Flat-pictures, Posters, Real-Objects, Improvisation and Chalkboard/Whiteboard, Cartoon, , Science and Technology corner, Flannel Board, Multimedia Projector, Computer Aided Instruction and Internet are available with the percentages ranging from 5% – 100%.
3. Textbooks, Charts, Posters, Real-Objects, Improvisation and Chalkboard/Whiteboard, Cartoon and Science and Technology corner are adequate with the percentages ranging from 1.67% - 100 %.
4. Problems associated with the implementation of Basic Science and Technology curriculum I Nigeria secondary schools are;
    i. No adequate instructional materials.
    ii. No teacher motivation.
    iii. No adequate classrooms.
    iv. No adequate funding.
    v. No adequate workshops and laboratories.
    vi. Lack of technology tools and equipment.
    vii. Insufficient power supply to operate the available Basic Science and Technology equipment.
    viii. None usage of resource person in the implementation of Basic Science and Technology.
    ix. Basic Science and Technology teachers develop apathy to workshop practice due to lack of motivation.

Discussion of Findings

The issue of curriculum implementation assessment in Nigeria is vital, and its needs to be conducted time to time so as to ensure effective curriculum implementation in Nigeria and the world around. Thus, this research titled assessment of Basic Science and Technology curriculum implementation in Nigeria secondary schools revealed that, Basic Science and Technology Teachers uses all the teaching method available to them in implementing the curriculum content of Basic Science and Technology. This tallied with the findings of Onipe, (2014), Ubah and Shu'aibu, (2014) respectively, who found that the teachers place much emphasis on teaching method and the implementation of the course contents which is mostly dominated by the use of traditional techniques of instruction notably the lecture method to the detriment of other instructional strategies.

Finding number two and three indicated the instructional materials in the implementation of Basic Science and Technology curriculum in Nigeria Secondary Schools. Based on the

respondent's view on instructional materials, most of the schools lacked necessary instructional materials. It was further revealed that the instructional materials that are available are not adequate. This agreed with the Kelly's view (1999) who opined that teaching and learning resources are challenge to curriculum implementation. There is limited procurement and supply of these resources in schools. Instructional materials and equipment are all in short supply or may not be available at all – no books or writing material, no science apparatus, inadequate or out of-date library.

The forth finding revealed that, there is no significant difference in the problems identified with the implementation of Basic Science and Technology curriculum in Nigeria Secondary Schools. This finding indicated that problems existed in the implementation of Basic Science and Technology curriculum includes; no adequate instructional materials, no teacher motivation, no adequate classrooms, no adequate funding, no adequate workshops and laboratories, lack of technology tools and equipment, insufficient power supply to operate the available Basic Science and Technology equipment, none usage of resource person in the implementation of Basic Science and Technology and Basic Science and Technology teachers develop apathy to workshop practice due to lack of motivation. These problems are significantly affecting the implementation of Basic Science and Technology curriculum. This tallied with the findings of Igbokwe, (2015) who revealed that, the problems against the implementation of Basic Science and Technology has significant effect on its implementation at secondary school levels, lack of materials and facilities including current textbooks, equipped library or workshop are the greatest problem affecting the implementation of Basic Science and Technology at the secondary school levels, there is no adequate commitment on the part of the government to ensure appropriate implementation of the Basic Science and Technology curriculum

Conclusion

The study assess the implementation of Basic Science and Technology in Junior Secondary Schools and the objectives set for this purpose is to determine the teaching methods used, availability and adequacy of instructional materials and the problems associated with the implementation of Basic Science and Technology curriculum.

The main findings of the study revealed that Basic Science and Technology teachers often used all the teaching methods available to them in the implementation of Basic Science and Technology curriculum, that Textbooks, Charts, Flat-pictures, Posters, Real-Objects, Chalkboard/Whiteboard, Cartoon, Flannel Board, Multimedia Projector, Computer Aided Instruction and Internet are available with the percentages ranging from 5% – 100% and Textbooks, Charts, Posters, Real-Objects, Chalkboard/Whiteboard and Cartoon are adequate with the percentages ranging from 1.67% - 100 %.

The findings further revealed some Problems associated with the implementation of Basic Science and Technology curriculum I Nigeria secondary schools are;

i. No adequate instructional materials.
ii. No teacher motivation.
iii. No adequate classrooms.
iv. No adequate funding.
v. No adequate workshops and laboratories.
vi. Lack of technology tools and equipment.
vii. Insufficient power supply to operate the available Basic Science and Technology equipment.
viii. None usage of resource person in the implementation of Basic Science and Technology.

ix. Basic Science and Technology teachers develop apathy to workshop practice due to lack of motivation.

Recommendations

Based on the research findings and what have been concluded, the following recommendations were made to help in effective implementation of Basic Science and Technology curriculum in Nigeria:

1. All people concerned with the implementation of curriculum content to start from teachers, principals, parents, and supervisors should be actively involved and committed to ensure the effective implementation of Basic Science and Technology curriculum in Nigeria;
2. Basic Science and Technology teachers need to be conversant with the appropriate and innovative teaching methods and strategies and as well employ them while teaching Basic Science and Technology;
3. Basic Science and Technology instructional materials and resources should be made available to the schools, and Basic Science and Technology teachers also need to be knowledgeable on how to make use of modern instructional materials;
4. There is need to consider teacher motivation, and provide adequate classrooms for Basic Science and Technology lesson. The students and community members need to be interested and give active support to the teaching and learning Basic Science and Technology as an educational programme.
5. Quality assurance officials should put more effort and perform their duties accordingly.

REFERENCES

Adeniyi, E.O. (2017). *9 – Year basic science and technology curriculum.* Abuja. Curriculum Development Centre, NERDC.

Ben-Yunusa, M. (2020). *Issues on Curriculum.* Zaria: ABU Press. Pg 27-45

Chukwuneke, B.U & Chikwenze A.R (2022). The extent of implementation of universal basic Education (UBE) programme in Nigeria: focus on Basic science curriculum. *Journal of Research and Development*, 4 (1) 116-126.

Damole, B. T. (2021) Emerging Issues on the Universal Basic Education Curriculum in Nigeria: Implications for the Science and Technology Component: *Pakistan Journal of Social Science,* Vol. 8 Issue 1.

Doggoh, B.T. (2017). *The Rudiments of Curriculum and Instruction*. Benue: Eddison Publishers.

Eya, N.M & Elechi C.N (2021). Availability of Basic Science Laboratory Facilities in junior secondary schools: A panacea for Reform in STEM Education. *STAN Conference Proceedings*. (8).

Federal Ministry of Education (2017). 9-year basic education curriculum: Basic Science & Technology: Nigeria Educational Research and Development Council (NERDC).

Guga, A. & Bawa, M.R. (2022). *Curriculum Innovation and Implementation*. Zaria: Kareem and Guga Publishers.

Nwosu, A. A. & Ibe, E. (2022). Assessment of teacher level of implementation of basic science curriculum: Implications for professional development. *53rd STAN annual conference proceedings.*

Obioma G.O. (2022). An Address Delivered at the Critique Workshop on Teacher's Guides for the Revised 9-Basic Education curriculum(BEC) Held at NERDC Conference Centre, Lagos Nigeria, 26-28th November, 2022.

Obioma, G. (2017). *9 – Year Basic Education Curriculum.* Abuja Nigerian Educational Research and Development Council (NERDC).

Osborne, J. and Collins, S (2021). Pupils' views of the role and value of the science curriculum: a focus-group study. *International Journal of Science Education*, 23 (5):441-467.

Peruse, J. (2000). In Ahmed, I. (2021). A Teachers' Roles in the Implementation of Hausa Language curriculum in Senior Secondary Schools in Kaduna State. (M. ed. Thesis) Zaria: Ahmadu Bello University.

Ubrebu, K. (1985). In Yusuf, H. O. (2022), *Fundamentals of Curriculum and Instruction.* Kaduna: Joys Graphics Printers and Publishers.

UNESCO (2000*). State of Education in Nigeria*. Lagos: Excellence Systems Ltd.

Yusuf, H. O. (2022), *Fundamentals of Curriculum and Instruction.* Kaduna: Joys Graphics Printers and Publishers.

SUB-THEME 14
HOME ECONOMICS

CONSUMPTION OF FRUITS, VEGETABLES, SNACKS, AND SUGAR- SWEETENED BEVERAGES AMONG UNDERGRADUATE STUDENTS OF ONDO STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY

[1]Olarewaju, C.A., [2]Bello, M., & [3]Oghen, F. M.
[1,2,3] Home Economics Department, Adeyemi Federal University of Education, Ondo
Corresponding Author: cecilia_abiodun@yahoo.co.uk; Phone number: +234 8059348564

Abstract

This study was carried out to assess Fruits, Vegetables, Snacks, and Soft Drinks Consumption among Undergraduates in Ondo State University of Science and Technology (OSUSTECH), Okitipupa. Five research questions guided the study. A cross-sectional survey research design was adopted for this study. Cluster sampling technique and balloting were used, and data were collected using a structured questionnaire from Two Hundred and ten (210) respondents. Data collected were analyzed using descriptive statistics and inferential statistical tests. Findings from the respondents showed that most of the undergraduates (54.29%) eat fruits in between meals, more than half (71.90%) incorporate vegetables into their diet, and most of them consume fruits, especially watermelon (21.43%). Also, most of the undergraduates (78.00%) eat snacks and take soft drinks (62.86%) in-between meals, (42.38%) twice a week, majority (61.43%) incorporate soft drinks into their diet, most of them consume soft drinks, especially coke (31.43%), twice times in a week (38.57%). Furthermore, Personal taste ($\bar{x}$ = 3.32), Cultural background ($\bar{x}$ = 3.27), Previous exposure to certain fruits and vegetables ($\bar{x}$ = 3.42), and Texture and flavor ($\bar{x}$ = 3.58) were notable factors influencing the consumption of fruits and vegetables among undergraduates in OSUSTECH. While, Availability ($\bar{x}$ = 3.55), Affordable pricing ($\bar{x}$ = 3.14), Peer pressure ($\bar{x}$ = 2.63), Taste of certain snacks and soft drinks ($\bar{x}$ = 2.78), Stress ($\bar{x}$ = 3.18), Aggressive marketing ($\bar{x}$ = 3.39), and Social media ($\bar{x}$ = 3.43) were factors influencing the consumption of snacks and soft drinks among undergraduates in OSUSTECH. The study concludes that understanding the types and frequency of fruits, vegetables, snacks, and soft drinks consumption among undergraduates highlights the need for targeted nutritional education and intervention programs. It was therefore recommended that educating the undergraduates on the health risks of soft drinks and snack consumption at religious or professional organizations is necessary. Also, increased efforts are needed to increase public awareness of the dangers associated with non-consumption of fruits and vegetables, among others.

Keywords: Fruits, vegetables, snacks, sugar- sweetened beverages, awareness, benefits and risks

Introduction

Undergraduate years represent a pivotal period during which young adults establish dietary patterns that can persist into later life. The transition to university often brings newfound autonomy, irregular schedules, and exposure to diverse food environments, all of which contribute to suboptimal eating behaviors (Mikolajczyk, Maxwell, & El Ansari, 2018). As emerging adults navigate academic pressures and social engagements, they may deprioritize balanced nutrition, increasing their risk for both immediate and long-term health consequences.

Fruits and vegetables are foundational to a health- promoting diet, providing essential micronutrients, dietary fiber, and bioactive phytochemicals that collectively mitigate the risk of chronic diseases such as cardiovascular disease, certain cancers, and obesity (Bellavia,

Larsson, Bottai, Wolk, & Orsini, 2018). The World Health Organization recommends a minimum daily intake of 400 g of fruits and vegetables, yet global surveys consistently reveal that young adults fall short of this benchmark (World Health Organization, 2019). Understanding the specific types and frequency of fruit and vegetable consumption among undergraduates is thus crucial for tailoring nutrition- promotion initiatives.

Despite well- documented benefits, consumption of fruits and vegetables remains low in many tertiary settings. In Nigerian universities, studies report that fewer than one in five undergraduates meet the recommended daily servings, with common barriers including limited availability on campus, high cost relative to processed foods, and lack of culinary skills or motivation to prepare fresh produce (Ademiluyi, 2016). Assessing the types and frequency of fruits and vegetables consumption among undergraduates at OSUSTECH will pinpoint critical gaps and inform targeted strategies to increase intake.

Conversely, the consumption of energy- dense snacks and sugar- sweetened beverages has surged among university students. Snacks high in refined sugars, unhealthy fats, and sodium—such as fried pastries, packaged chips, and confectioneries—contribute to excess caloric intake and adverse metabolic outcomes (Shaik, Bhateja, Arora, & Prathyusha, 2020). Regular consumption of sugar- sweetened beverages, including sodas and energy drinks, exacerbates risks for dental caries, type 2 diabetes, and poor weight management (Shree, Prasad, Kumar, Sinha, & Choudhary, 2018). Studying the types and frequency of snacks and soft drinks consumption among undergraduates at OSUSTECH will elucidate prevailing patterns that warrant intervention.

In the Nigerian context, up to 86.5% of undergraduates report daily soft drink intake, often driven by taste preferences, aggressive marketing, and the perception of these beverages as symbols of modernity and social belonging (National Bureau of Statistics, 2020). Similarly, convenient but nutritionally poor snacks dominate campus vending machines and local outlets, creating an obesogenic environment that undermines healthy choices. Documenting these consumption behaviors will help university stakeholders prioritize environmental modifications and policy actions.

Awareness of nutritional recommendations does not necessarily translate into healthy eating practices. Although many students acknowledge that fruits and vegetables support immune function and chronic disease prevention, a persistent "knowledge–behavior" gap exists: academic workloads, cost concerns, and taste preferences frequently override health considerations, leading to continued reliance on unhealthy snacks and drinks (Deliens, Clarys, De Bourdeaudhuij, & Deforche, 2018). Understanding the level of awareness of the health benefits of fruits and vegetables and the risks associated with snacks and soft drinks among these students will assess this critical dimension.

Finally, exploring the association between awareness and actual consumption patterns (Research Hypothesis 3) is essential for determining the efficacy of knowledge- based interventions alone. If awareness proves only weakly correlated with behavior, comprehensive strategies—such as modifying campus food environments, implementing fiscal measures (e.g., subsidies for fresh produce), and integrating practical cooking modules into student orientations—will be required to bridge the gap between knowing and doing. The findings will enable policymakers and university administrators to design multifaceted, evidence- based programs that foster a campus culture of holistic well- being.

Statement of the Problem

The dietary choices of undergraduates at OSUSTECH reveal a troubling duality: while fruits and vegetables offer essential nutrients that underpin lifelong health, they remain markedly under-consumed; concurrently, energy-dense snacks and sugar-sweetened beverages dominate students' diets, heightening risks for obesity, metabolic disorders, and dental

problems (Ademiluyi, 2016; Shree, Prasad, Kumar, Sinha, & Choudhary, 2018). Despite widespread awareness of nutritional guidelines, the disconnect between knowledge and behavior persists, driven by factors such as cost constraints, limited campus availability of fresh produce, and the allure of convenient, palatable alternatives (Deliens, Clarys, De Bourdeaudhuij, & Deforche, 2018; National Bureau of Statistics [NBS], 2020). This imbalance not only undermines students' immediate well-being but also establishes unhealthy patterns that can extend into adulthood. Therefore, it is imperative to assess the specific consumption frequencies and patterns of both healthy and unhealthy foods, alongside evaluating the extent to which awareness influences actual dietary behaviors, in order to inform targeted interventions that can effectively bridge the gap between knowing and doing.

Research Questions

The following questions guided the study:

1. What are the types and frequency of fruits and vegetables consumption among undergraduates at OSUSTECH?
2. What are the types and frequency of snacks and soft drinks consumption among undergraduates at OSUSTECH?
3. What is the level of awareness of the health benefits of fruits and vegetables and the risks associated with snacks and soft drinks among undergraduates at OSUSTECH?

Research Hypothesis

The following null hypothesis was tested at 0.05 level of significance.

H_0 : There is no significant association between undergraduates' level of awareness of the health benefits and risks of fruits, vegetables, snacks, and soft drinks and their actual consumption patterns.

Methodology

This study employed a cross- sectional survey design to assess the consumption patterns of fruits, vegetables, snacks, and soft drinks, as well as the level of nutritional awareness among undergraduates at OSUSTECH. A cross- sectional design enables the simultaneous collection of data on exposures (e.g., awareness) and outcomes (e.g., consumption behaviors) at a single point in time, facilitating the estimation of prevalence and the examination of associations between variables (Osuala, 2016).

The study was conducted at Ondo State University of Science and Technology (OSUSTECH), Okitipupa, Nigeria, which has an undergraduate population of 4,222 students according to the Registry Department (2024). OSUSTECH's diverse student body and campus food environment provide an appropriate context for examining dietary behaviors and knowledge.

A sample of 210 undergraduates (approximately 5% of the total population) was drawn using a two- stage cluster sampling approach. First, seven academic departments were selected via simple balloting. Second, within each selected department, 30 students were chosen through systematic random sampling of class lists to ensure representation across gender, level of study, and discipline.

Data were collected using the "Fruits, Vegetables, Snacks and Soft Drinks Consumption Questionnaire (FVSSSCQ)," a structured, self- administered instrument comprising four sections: demographic information; types and frequency of fruits/vegetables consumption; types and frequency of snacks/soft drinks consumption; and awareness of associated health benefits and risks. Items on consumption frequency were rated on a 4- point Likert scale (1 = "Strongly Disagree" to 4 = "Strongly Agree"), allowing for quantitative comparison of patterns.

Content validity was established through expert review by the project supervisor and two senior lecturers in Home Economics, who assessed item relevance and clarity. A pilot test was conducted with 20 students outside the main sample. Test–retest reliability was evaluated over a two- week interval, and internal consistency was assessed using Cronbach's alpha, with coefficients ≥ .70 considered acceptable (Tavakol & Dennick, 2011).

After obtaining ethical clearance and informed consent, the researcher and an assistant administered 210 questionnaires in lecture halls and common areas over a two- week period. Completed surveys were collected immediately to minimize non- response and data loss.

Data were analyzed using SPSS Version 25. Descriptive statistics (frequencies, percentages, means, and standard deviations) summarized consumption patterns and awareness levels. To test the association between awareness and consumption behaviors (Research Hypothesis H_0), Pearson's correlation and chi- square tests were applied at a 0.05 significance level.

Results

Research Question 1: *What are the types and frequency of fruits and vegetables consumption among undergraduates at OSUSTECH?*

Table 1. Types and Frequency of Fruits and Vegetables Consumption (n = 210)

Fruit/Vegetable	Daily (%)	3–4×/wk (%)	1–2×/wk (%)	Rarely/Never (%)
Citrus (e.g., orange)	15.7	26.2	38.1	20.0
Mango	12.9	23.8	42.4	20.9
Pawpaw	10.5	18.6	48.6	22.3
Pineapple	11.4	16.7	45.7	26.2
Banana	18.6	28.1	37.6	15.7
Avocado	9.5	14.8	40.0	35.7
African Star Apple	8.6	12.9	36.7	41.9
Soursop	7.6	10.0	34.3	48.1
Sweetsop	6.7	9.0	32.9	51.4
Breadfruit	5.7	8.6	30.5	55.2

Bananas and citrus fruits were the most frequently consumed items, with 18.6% and 15.7% of students eating them daily. Tropical fruits like soursop, sweetsop, and breadfruit showed very low daily intake (≤ 7.6%) and high "Rarely/Never" rates (> 48%). Overall, fewer than one in five undergraduates met daily consumption for any individual fruit or vegetable, underscoring a shortfall against WHO recommendations.

Research Question 2: *What are the types and frequency of snacks and soft drinks consumption among undergraduates at OSUSTECH?*

Table 2. Types and Frequency of Snacks and Soft Drinks Consumption (n = 210)

Snack Type	Daily (%)	3–4×/wk (%)	1–2×/wk (%)	Rarely/Never (%)
Chin-chin	38.6	25.7	21.0	14.7
Puff-puff	35.2	23.8	24.8	16.2
Doughnut	29.5	20.5	28.6	21.4
Pie/Rolls	26.7	18.1	30.0	25.2
Chips (packaged)	41.0	27.6	19.5	11.9
Candy/Chocolate	33.3	22.4	25.7	18.6
Soft Drink Type	**Daily (%)**	**3–4×/wk (%)**	**1–2×/wk (%)**	**Rarely/Never (%)**
Coca-Cola	54.8	23.3	13.8	8.1
Fanta	49.5	21.0	17.6	11.9
Sprite/Seven Up	45.7	19.5	18.6	16.2
Pepsi	42.9	18.6	20.0	18.6
Malt Drinks	37.1	16.7	22.4	23.8

Energy Drinks	25.2	15.7	28.1	31.0

Packaged chips (41.0%) and chin-chin (38.6%) were the most common daily snacks, while doughnuts and pie/rolls had lower daily rates. For beverages, Coca-Cola led daily consumption (54.8%), followed by Fanta (49.5%). Energy drinks were less frequently consumed, with only 25.2% daily uptake and 31.0% rarely or never.

Research Question 3: *What is the level of awareness of the health benefits of fruits and vegetables and the risks associated with snacks and soft drinks among undergraduates at OSUSTECH?*

Table 3. Awareness of Health Benefits and Risks (n = 210)

Statement	% Agree	Mean (SD)
"Regular fruit and vegetable intake prevents chronic diseases."	88.6	3.58 (0.62)
"High snack consumption increases risk of obesity and diabetes."	74.3	3.22 (0.74)
"Soft drinks contribute to dental caries and weight gain."	82.4	3.45 (0.68)
"I know the recommended daily servings for fruits and vegetables."	62.9	2.89 (0.81)

A large majority recognize that fruit/vegetable intake prevents chronic illness (88.6%) and that sugary snacks and soft drinks pose health risks (> 74%). Only 62.9% felt confident about the official serving recommendations, highlighting a gap in specific guideline awareness.

Research Hypothesis (H_0): *There is no significant association between undergraduates' awareness levels and their actual consumption patterns.*

Table 4. Correlation between Awareness and Consumption Patterns (n = 210)

Variables	r	p-value
Awareness vs. Fruit/Vegetable Intake	0.41	< .001
Awareness vs. Snack/Drink Intake	–0.35	< .001

Awareness correlates moderately and positively with healthy consumption (r = .41) and moderately and negatively with unhealthy consumption (r = –.35), both at $p < .001$. Therefore, we reject H_0 : greater nutritional awareness is significantly associated with better dietary choices among undergraduates.

Discussion of Findings

The low frequency of fruit and vegetable consumption—particularly the fact that fewer than one in five students eat even common items like bananas or citrus daily—mirrors broader trends observed among university populations globally (Bellavia *et al.*, 2018; World Health Organization, 2019). Despite wide recognition of their protective effects against chronic disease, undergraduates at OSUSTECH face practical barriers such as limited on-campus availability and perceived cost or preparation constraints (Ademiluyi, 2016). These findings suggest that awareness alone is insufficient; institutional measures—such as subsidized produce, improved dining- hall offerings, or on-campus farmers' markets—are needed to translate positive attitudes into sustained behavior change.

Daily consumption of energy- dense snacks and sugar-sweetened beverages far outstrips healthy alternatives, with packaged chips and Coca-Cola leading the rankings. This obesogenic pattern aligns with studies showing that convenience, taste preference, and aggressive marketing drive high snack and soft drink uptake among young adults (Shaik *et al.*, 2020; National Bureau of Statistics [NBS], 2020). The predominance of nutrient-poor options not only undermines students' metabolic health but also reinforces social norms that valorize convenience foods. Comprehensive campus policies—such as limiting the sale of

high-calorie snacks in vending machines and promoting water or low-sugar alternatives—could help shift consumption toward healthier choices.

Although general awareness of fruits and vegetables' role in preventing chronic diseases and of the risks posed by snacks and soft drinks was high (mean agreement ≥ 3.22), only 62.9% of undergraduates felt confident about the specific recommended daily servings. This "knowledge–behavior gap" echoes findings that broad nutritional literacy does not guarantee accurate understanding of guidelines, which can hinder effective self-regulation (Deliens, Clarys, De Bourdeaudhuij, & Deforche, 2018). To address this, educational interventions should include clear, actionable information on portion sizes and serving frequencies, perhaps integrated into orientation programs or mobile-app reminders.

Finally, the moderate positive correlation between awareness and fruit/vegetable intake ($r = .41$) and the inverse correlation with snack/soft drink consumption ($r = –.35$) indicate that knowledge does influence behavior, but not decisively (Graham & Laska, 2021). This underscores the need for multifaceted strategies: enhancing awareness must be coupled with environmental modifications, fiscal incentives, and practical skills training (e.g., cooking workshops) to strengthen the translation of knowledge into sustained healthy behaviors.

Conclusion

Undergraduates at OSUSTECH demonstrate suboptimal intake of fruits and vegetables alongside high reliance on energy- dense snacks and sugar- sweetened beverages, despite strong general awareness of their health implications. Nutritional knowledge correlates with healthier choices but is insufficient to drive behavior change alone. Therefore, integrated strategies that combine targeted education, improved food environments, and fiscal incentives are essential to promote lasting dietary improvements.

Recommendations

- School management and student Union Government should work together to subsidize fresh produce in campus dining halls and establish weekly farmers' markets.
- Home Economics programme should integrate practical nutrition modules into student orientation that emphasize portion sizes and serving recommendations.
- Food-producing companies around the institution should restrict high-calorie snacks and sugary beverages in vending machines; promote water and low-sugar alternatives.
- Home Economics department should offer cooking demonstrations and meal- planning sessions to empower students to prepare quick, affordable, and healthy meals.
- The State Ministries of Education and Health should implement loyalty or discount programs for purchasing fruits and vegetables through the campus food- card system.

References

Ademiluyi, F. (2016). *Fruit fortification strategies to improve micronutrient intake in Nigeria*. University Press.

Bellavia, A., Larsson, S. C., Bottai, M., Wolk, A., & Orsini, N. (2018). Fruit and vegetable consumption and risk of non-communicable diseases: A dose-response meta-analysis. *Journal of Epidemiology and Community Health, 72*(9), 960–966. https://doi.org/10.1136/jech-2017-210810

Deliens, T., Clarys, P., De Bourdeaudhuij, I., & Deforche, B. (2018). Determinants of eating behaviour in university students: A qualitative study. *Appetite, 125*, 201–206. https://doi.org/10.1016/j.appet.2018.01.008

Graham, D. J., & Laska, M. N. (2021). Longitudinal associations in sugary beverage intake and weight gain among university students. *Public Health Nutrition, 24*(10), 3020–3027. https://doi.org/10.1017/S1368980021001984

Mikolajczyk, R. T., Maxwell, A. E., & El Ansari, W. (2018). Eating habits and dietary acculturation among university students. *Nutrition Journal, 17*(1), 60. https://doi.org/10.1186/s12937-018-0386-z

National Bureau of Statistics. (2020). *Nutritional status and consumption patterns of Nigerian students*. Abuja, Nigeria: Author.

Shaik, A., Bhateja, P., Arora, R., & Prathyusha, P. (2020). The influence of snack consumption on health outcomes among young adults. *International Journal of Food Sciences, 15*(4), 210–218. https://doi.org/10.3390/foods15040210

Shree, S., Prasad, R., Kumar, N., Sinha, A., & Choudhary, S. (2018). Impact of sugar-sweetened beverages on adolescents' health: A review. *Journal of Health Sciences, 8*(2), 45–52. https://doi.org/10.17582/journal.jhs/2018/8.2.45.52

World Health Organization. (2019). *Global strategy on diet, physical activity and health*. Geneva, Switzerland: Author.

SOCIOCULTURAL INFLUENCES ON THE EATING BEHAVIOURS OF ADOLESCENTS IN ONDO EAST LOCAL GOVERNMENT AREA OF ONDO STATE

Oseyemi Esther AKINYOTU(Ph.D.)
oseakin@gmail.com /07031232935
Department of Home Economics
Adeyemi Federal University of Education, Ondo.

Abstract

The study evaluated the Sociocultural Influences on the eating behaviors of adolescents in Ondo East Local Government Area of Ondo State. Four research questions guided the study. Two (2) null hypotheses were formulated and tested at 0.05 level of significance. Descriptive research design was adopted. The total population of the study consisted of all junior secondary school students in selected public secondary schools (2678), Using Yaro Tamene formular, two hundred and eighty-nine (289) respondents were selected as the sample size of the study. Simple random sampling method was used to select four (4) out of the twelve schools in the study. A structured questionnaire titled "Sociocultural Influences on the Eating Behavior of Adolescents Questionnaire (SIEBAQ) was used to elicit responses from the selected respondents. Spilt-half reliability method was used to determine the internal consistency of the instrument and correlation coefficient was obtained. Data obtained were analyzed using both descriptive (frequency, mean and standard deviation) and inferential statistics (one-way Anova). Findings from the study revealed that the food consumed by the majority are often associated with food insecurity status or severe food shortage with X of 3. 20, socioeconomic status of parents determines food consumption pattern among adolescents with X of 2. 96. The study concluded that the eating behavior of adolescents has no significant influence on the socio-cultural diet of adolescents and physical activity. Based on the research findings, it was recommended that adolescents should be educated on healthy eating behavior and practice healthy lifestyles.

Keywords: Adolescents, Eating Behaviors, Sociocultural Influences

Introduction

The profound significance of food is for eliminating famine, food insecurity and providing adequate nutrition for all categories of individuals throughout the world. The importance of food consumption cannot be over-emphasized even in the world today, where the state of nutrition in each country, state and tribe is very relevant and important to each respectively. Taking down the memory lane, human history tells us that there have been many restrictive or stringent taboos on what people eat, how it is processed and eaten. Differences in races and in cultural levels complicated the eating behavior of all human, it was only too easy to insist that fewer breeds someway, in a divine manner would necessarily be less fed, due to lack of prudent economy. All humans eat to survive, to express appreciation, for a sense of belonging, as a part of family customs and for self-realization. For example, someone who is not hungry may eat a piece of cake that has been baked in his or her honor.

Eating behavior incorporates the extensive variety of actions and habits associated to why and how people eat, which food they eat as well as the way people obtain, store, use and discard food. It can be linked to the motive behind dieting and food habits. The patterns of an individual's food and beverage consumption habits, indicated by food choices, meal

frequency and portion size. Clennan, Carucci, Alert, Collins, Ettzel, LaRoche, Leeder and Saab (2019). Individual, social, cultural, religious, economic, environmental and political factors influence people's eating behavior. Socio factors and cultural practices in most countries have a great influence on what people eat, how they prepare their food. their feeding practices and the food they prefer. All people have their likes and dislikes about food. Many people are conservative to their eating behavior because they eat according to learned behaviors regarding etiquette, meal and snack pattern, acceptable foods, foods combination and portion size. Dubois, Bedard, & Goulet (2022). A common eating pattern is three meals (breakfast, lunch and dinner) per day with snacks between meals. The mechanisms of a meal differ across cultures, but largely comprise grains, such as rice, spaghetti; meat or a meat substitute, such as fish, beans or rice, and accompaniments such as vegetables, fruits. Eating behavior is a typical behavior correlated to eating habits, choosing foods that you eat; culinary preparations and measures of absorption. Eating well can become a habit and so can eating poorly. Eating poorly might help develop serious diseases as obesity, malnourishment, among others. Food habits and obesity can barely be separated. The rational for that is, that the way some individual eats determines his/her health status. Eating Behaviors maybe based on advice from friends and family, television and the media, from the variety of diet books available, or from the latest trendy diets. Cultural background shapes by food preferences, with certain foods being considered staples or delicacies in different cultures. Hence, eating behavior are intricately linked to culture, reflecting the values, traditions and social norms of a society.

Culture refers to the shared beliefs, values, practices, symbols and artifacts that distinguish groups in society. Culture according to Thoughtco; a sociologist encompass language, communication systems, values, beliefs, and shared practices. Personal values, attitudes and beliefs about food and food preferences are largely shaped during the early socialization period and are accordingly now a product of culture. Food chosen, methods of cooking, eating pattern, food preparation, number of meals per day, time and size of portion eaten make up human eating behaviors and are a part of intelligible culture in which each custom and practices has a part of. Sociocultural factors are spread from one generation to the other by the process of socialization. Food habits differ widely regarding which foods are liked, disliked, eaten or not eaten in the society. Cultural groups provide guidelines regarding acceptable foods, foods combination, eating pattern and eating behaviors compliance with these guidelines create sense of identity and belonging for individual. Someone who is repeatedly exposed to certain food is less hesitant to eat them, for example, lobster, traditionally was only available on the coasts and is much more likely to be accepted as food by coastal dwellers. Religion may have important role in forbidding the consumption of certain foods for example, neither the Muslim nor the Jewish people consume pork. Within Christianity, the Seventh Day Adventist discourage stimulating beverage such as alcohol which is forbidden among Catholics. Food habits and customs do change, and they are influenced in many ways. Cultural background shapes food preferences, with certain foods being considered staples or delicacies in different cultures; this determines what eating behaviors are acceptable or expected during adolescence period.

Adolescence is a transitional life phase characterized by marked bio psychosocial changes potentially capable of determining the future health status in adulthood. It is also during this phase that habits are established and health-related behaviors either positive or negative, are adopted, often persisting throughout adulthood. Adolescence is a unique stage of human development that identifies the phase between childhood and adulthood by experiencing rapid physical, cognitive and psychological growth. The transition from widespread under nutrition to increasing overweight and obesity has emerged as a complex

challenge facing the adolescents in low and middle-income areas historically affected by food insecurity. The food environment in low and middle-income areas changed drastically as globalization of food markets, lowering of manufacturing cost of edible oils, caloric sweeteners and increased production of animal-source foods paved the way for abundant availability of cheap, energy-dense foods and beverages. Although adolescents' energy intake has risen, the diets remain limited in diversity leading to dietary patterns unconducive to a healthy lifespan free from nutrition-related non- communicable diseases. Unhealthy dietary practices and eating habits among adolescents involving less consumption of fruits and vegetables, snacking, frequent consumption of sugar-sweetened beverages and tendency to skip breakfast combined with an increase in screen-based recreational behaviors like watching television, playing games and using social media have exposed adolescents globally to a higher likelihood of adverse health outcomes in their ensuring adulthood exploration of dietary and physical activity behaviors in this population is therefore , of notable public health interest.

Poor eating habits formed during adolescence can lead to obesity and diet-related diseases in later years. The high incidence of dieting behaviors can contribute to nutritional inadequacies and to the development of eating disorders. Nutritional needs during adolescence are increased because of the increased growth rate and changes in body composition associated with puberty. Primary care providers are in an optional position to provide nutrition screening, counselling to the adolescent patient and caregivers and referral to a dietician if needed. The dramatic increase in energy and nutritional requirements coincides with other factors that may affect adolescents' food choices, nutrient intakes and thus, nutritional status. These factors, including the quest for independence and acceptance by peers, increased mobility, and greater time spent at school and work activities and pre-occupation with self-image contribute to the erratic and unhealthy eating behaviors that are common during adolescence. Adolescence may have formed beliefs about their cultural foods and eating habits that reflect their family's notions of healthy and unhealthy foods, which may or may not be accurate (Demory-Luce & Motil 2023)

In early adolescence, young people tend to adopt lifestyles and habits that could play a determining role in their future health. At this early age, they begin to develop their independence, while continuing to be influenced by their sociocultural environment. Sociocultural factors have an impact on eating habits and physical activity, and this is even more evident in adolescence when youths are in the process of learning and experiments.

It is on this note that this study tends to find out sociocultural influences on the eating behaviors of adolescents in Ondo East Local Government Area of Ondo State.

Statement of the problem

Adolescence period is a serious developmental phase during which individuals create lifetime eating habits that expressively affect their health and well-being. Lately, this matter of eating behavior among adolescents has become an issue of concern which needs urgent attention because of the unhealthy eating behaviors amongst adolescents, including augmented consumption of fast food, skipping meals, and poor dietary choices that contribute to malnutrition, obesity and other health challenges. Adolescents are more vulnerable to social influences through the internet, peer group, family traditions, religious practices among many others and these play a crucial role in shaping adolescents' insights of food and eating habits. In Ondo East, a rural area where varied folkloric groups coexist, these sociocultural influences are multifaceted. Traditional beliefs about body image, gender roles in food preparation, and communal eating patterns may affect dietary behavior differently than in urbanized contexts. Regardless of the importance of these influences, there is a paucity of localized research examining how sociocultural dynamics precisely affect adolescent eating behavior in Ondo

East. Without rich understanding and empirical evidence, public health interferences and nutrition education curricula may fail to address the origin causes of unhealthy eating patterns among adolescents in Ondo East Local Government of Ondo State. The rate at which adolescents in higher institutions consume junks and carbonated drinks is very alarming. All those unhealthy eating behaviors can cause diet- related diseases in the later years. In view of this, the study investigated the Socio-cultural influences on eating behavior of Adolescents in Ondo East Local Government Area of Ondo State.

Purpose of the study

The main purpose of the study was to examine the Socio-cultural influences on eating behaviors of adolescents in Ondo East Local Government Area of Ondo State. Specifically, the study:

1. Documented the socio-cultural factors that influence the food choices of Adolescents
2. Examined the risk factors that contribute to the eating behavior of adolescents
3. Found out the impact of Socio-cultural influences on adolescent diet, physical activity and body shape.
4. Examined the eating behavior of adolescents

Research Questions

The following research questions were raised to guide the study:

a. What are the sociocultural factors that influence the food choices of adolescents?
b. What are the risk factors that contribute to the eating behavior of adolescents?
c. Do sociocultural influences have impact on Adolescents diet, physical activity and body shape?
d. What are the eating behaviors of adolescents?

Hypothesis of the study

The null hypothesis was formulated and tested at 0.05 level of significance.

Ho: There is no significant differences in the mean responses of respondents on the Eating Behavior of Adolescents and its Socio-cultural influences on Adolescents diet and physical activity.

Methodology

Research Design

A descriptive research design was used in this study. The design was adopted to assist in describing and interpreting opinion, ideas and fact as expressed by respondents.

Area of the Study

The study was carried out in Ondo East Local Government Area of Ondo State. Ondo East Local Government is one of the 18 Local Government Areas in Ondo State. The main occupation of people in this area is farming and trading but due to education they now engage in teaching, banking, nursing and civil services but not all. Its headquarters is in the town of Bolorunduro. The local government occupies an area of approximately 896km and a population of 76,096 according to the 2006 population census. It is located at the equatorial region and shares boundaries on the North with Idanre Local Government, on the South with Ondo West Local Government. Ile- Oluji/Oke-Igbo Local Government on the East and Atakimosa west in Osun State on the North Eastern part.

Population of the Study

The population of the study consisted of Junior Secondary School students in selected public secondary schools in Ondo East Local Government Area of Ondo state. In the local government there are 12 public secondary school with population of Two Thousand Six Hundred and Seventy-Eight (2678).

Source: Ministry of Education, Ondo East Local Government, 2023.

Sample and Sampling Techniques

Using Yaro Tamene Formular, a sample size of Two Hundred and Eighty-nine respondents (289) was randomly selected from the population of the study. Four (4) schools were randomly selected from the twelve (12) public schools in Ondo East Local Government Area of Ondo State. The number of respondents selected from each of the four (4) schools is 81, 55,112 and 40 from Holy Trinity Grammar school, Ondo, Temidire Community Igbo-oja, and OgoOluwa Community, Oboto respectively.

Instruments for Data Collection

The research instrument used for this research work was a structured questionnaire titled Sociocultural Influences on the Eating Behavior of Adolescents Questionnaire (SIEBQ). This questionnaire was used to elicit responses from respondents based on the proposed research questions raised for this study. The questionnaire was in four (4) sections. Section A consisted of personal data of the respondents; Section B consisted of fixed response item on sociocultural factors that influences food choices of adolescents, Section C consisted of impact of sociocultural influences on Adolescent diet, physical activities and body shape; Section D focused on the eating behavior of adolescents

Validation of Instrument

The research questionnaire was subjected to Content validity by the researcher and two other experts in Food and Nutrition Section in the Department of Home Economics, Adeyemi Federal University of Education, Ondo. Their observations, suggestions and comments were used to refine the final copy of the instruments and ensure its capability of providing information for realizing the research objectives.

Reliability of the Instrument

Twenty (20) copies of the instrument were administered once to adolescents outside the study area. Split half reliability method was used to determine the internal consistency of the instrument. A correlation coefficient of 0.75 was achieved and this indicated strong internal consistency.

Methods of Data Collection and Administration of Instruments

Two hundred and eighty-nine (289) copies of the questionnaire were produced and administered to adolescents by the researcher with the help of two briefed research assistants. The filled copies of the questionnaire were collected immediately to avoid loss in transit.

Methods of Data Analysis

The responses to the questionnaire was collected, collated and analyzed using mean and standard deviation. The null hypothesis was tested using one-way analysis variance of no significance value at the probability level of 0.05 of significance at relevant degree of freedom. Cut-off point (COP) of 2.50 was to determine acceptability or rejection of items. The decision point for the mean was that any mean of 2.50 above was considered agreed while any mean below 2.50 was considered disagreed**.**

Analysis of Research Questions

Research Question One: What are the sociocultural factors that influence the food choices of Adolescents

Table 3: Mean and Standard Deviation rating of the respondents on the sociocultural factors that influence the food choices of adolescents

S/N	ITEMS	$\bar{x}$	SD	REMARK
1	Adolescents food choices are learned mainly through transmission from parents	3.04	.813	Agreed
2	Adolescents use junks foods" to signal belonging to a peer group deficiency(ies)	2.96	.804	Agreed

3	Food consumed by the wealthy are often associated with refinements, while low-prestige foods are associated with food insecurity status or severe food shortage	3.20	.735	Agreed
4	Religions help define food practices through various rules, symbols and meanings	1.75	.939	Disagreed
5	Taste, price and convenience influences the food choice of adolescents	1.92	1.013	Disagreed
6	Environmental factors such as peer pressure, advertising is one of the determinants that influences adolescents food choices	2.86	.658	Agreed

Table 3 shows the mean and standard deviation of respondents on the socio-cultural factors that influence the food choices of adolescents. The respondents agreed with items 1.2, 3 and 6 with the mean rating 3.04, 3.11, 3.20 and 2.86 above the mean rating 2.50. Meanwhile. respondents disagreed with items 4 and 5 with the mean of1.75 and 1.92 respectively.

Research Question Two: Does sociocultural influences have impact on Adolescents diet, physical activity

Table 4: Mean and Standard Deviation Rating of the respondents on Impact of Adolescent diet, physical activity and body shape

S/N	Items	$\bar{x}$	SD	REMARK
1.	Adolescents in rural areas tend to have more nutritional problems compared to those in urban area	2.77	.313	Agreed
2.	Socioeconomic status of parents determines food consumption pattern among adolescents	2.96	.804	Agreed
3.	Religion food practices affects the intake of certain food and may cause nutrient deficiency(ies)	1.57	.698	Disagreed
4.	Adolescents in rural areas tends to consume fresh and natural foods compared to those in urban areas who consume high-fat and empty calorie food	1.73	.720	Disagreed

Table 4 shows the mean $\bar{x}$ and Standard deviation of respondents on the impact of sociocultural influences on adolescent's diet, physical activity and body shape. Respondents agreed with items 1 and 2 with the mean rating of 2.77 and 2.96 above the decision rule of 2.50. Meanwhile, respondents disagreed with items 3 & 4 with the mean of 1.57 and 1.73 respectively.

Research Question 3: What are the eating behaviors of Adolescents

Table 5: Frequency Distribution table showing the eating behavior of adolescents

Items	LEVELS	F	%	X^2	df
Do you skip any meals	Yes	77	26.6	0.002075	**1**
	No	212	73.4		
Do you eat lunch	Yes	267	92.4	0.0000649	**1**
	No	22	7.6		
Do you eat dinner	Yes	282	97.6	0.000615	**1**
	No	7	2.4		
Do you buy meals from vendors	Yes	187	63.7	0.000129	**1**
	No	105	36.3		
Do you eat	Yes	21	7.2	0.000194	**1**

snacks in-between meals	No	268	92.8		
Do you replace main meal with snacks	Yes	219	75.8	0.000073	**1**
	No	70	24.2		
Do you take carbonated or soft drinks	Yes	267	92.4	0.000065	**1**
	No	22	7.6		
Do you take alcoholic drinks/stimulating drinks	Yes	73	25.3	0.000253	**1**
	No	216	74.7		

Source: Field Survey 2023

Table 5 shows the eating behaviors of adolescents and its effect/implications on their health status. The table shows that 49% of the adolescents eats thrice in a day, 259% more than thrice and 25% twice while 2% eat once. Also, majority don't skip any meal as more than 70% agreed. More so, 92.4% agreed to eat lunch while 7.6% said NO. 97.6% eat dinner and 2.4% don't eat dinner.

Table 6: Frequency Distribution table showing the eating behavior of adolescents

ITEMS	LEVELS	F	%	X^2	df
How many times do eat in a day drink	Once	6	25	0.0372	**3**
	Twice	71	2		
	Thrice	142	49		
	More than thrice	70	24		
How often do you take carbonated	Once	188	65	0.5300	**3**
	Twice	81	28		
	Thrice	16	80		
	More than thrice	4	1		
How often do you take alcoholic/stimulating drinks	Once	231	20	0.00087	**1**
	Twice	58	25		
	Thrice	-	-		
	More than thrice	-	-		
What time do you eat breakfast	Before 1lam	221	76	0.0351	**1**
	After 1lam	68	24		
What time do you eat lunch	1-3pm	205	71	0.0170	**1**
	After 3pm	84	29		
What time do you eat dinner?	6-9pm	209	72	0.014	**1**
	After 9pm	80	28		

What type of meal do you buy from vendors	Breakfast	147	51	0.01802	**2**
	Lunch	130	45		
	Dinner	12	4		
How often do you take snacks	Everyday	80	28	0.0294	**2**
	Sometimes	117	40		
	Rarely	92	32		
Which meal do you replace with snacks	Breakfast	72	25	0.0135	**2**
	Lunch	208	72		
	Dinner	9	3		

Source: Field Survey 2023

Hypothesis testing

Ho1: There is no significant differences in the mean responses of respondents on the eating behavior of adolescents and its socio-cultural influences on adolescent diet and physical Activity.

Table 7: One-way Analysis of Variance summary showing difference in the mean responses of respondents on the eating behavior of adolescents and its socio- cultural influences on adolescent diet and physical activity

Sources of variance	**Degree of freedom**	**Sum of Square**	**Mean of Square**	**F-ratio**	**Sig**	**P**
Between Group	2	78.054	4.591	10.51	0.08	>0.05
Within Group	286	1061.656	3.918			
Total	**288**	**1139.71**				

Table 8 reveals that there is no significant difference in the mean responses of respondents on the eating behavior of adolescents and its socio-cultural influences on adolescent diet and physical activity; F (2, 286) = 10.51, p>0.05. Thus, the null hypothesis was accepted. The result shows that socio-cultural influences adolescent diet and physical activity do not have significant effect on the eating behavior of adolescents.

Discussion of Findings

The research work focused on the sociocultural influences on eating behavior of adolescents .The respondents agreed that food choices are learned mainly through transmission from parents; adolescents use junk foods to signal personal belonging to a peer group; food consumed by the wealthy are often associated with refinements, while low-prestige foods are associated with food insecurity status or severe food shortage; taste, price and convenience influences the food choice of adolescents; environmental factors such as peer pressure, advertising is one of the determinants that influences adolescents food choices. Adolescents eating behaviors are conceptualized as a function of individual and environmental influences with four levels which are individual or intrapersonal influences (psychosocial, biological); social environmental or interpersonal (family and peers); physical environmental or community settings (schools, fast food outlets, convenience stores); and

macro system or societal (mass media, marketing and advertising, social and cultural norms). Adolescents are expected to be fed on right diet, but malnutrition is a common nutritional problem due to poor diet and lack of health care services in some parts of the country Omobuwa, Alebiosu, Olajide and Adebimpe (2014). The adolescents therefore face series of serious nutritional challenges which would impact this rapid growth spurt as well as their health as well as their health as adults.

According to the findings of the study, it was revealed that the adolescents in rural areas tend to inadequate nutritional information compared to those in urban areas; this could be linked to the socioeconomic status of parents which is a major determinant of food choice and consumption pattern among adolescents. Adolescents in rural areas based on findings tend to consume fresh and natural foods compared to those in urban areas who consume high-fat and empty calorie food and this might be because of socialization, peer group influence among others. Glanz(2015) emphasized on the importance of considering the food environment and its impact on eating behavior i.e. human eating behavior is determined by the locally available food and the environment. In rural areas in Nigeria, malnutrition tends to be a common nutritional problem due to poor diet, lack of health care services among others. Adolescent malnutrition may be in the form of under-nutrition and over-nutrition which tend to constitute serious public health problems affecting both developed and developing countries (WHO, 2016). Malnutrition and its consequences are large contributors to deaths, physical deformities and disabilities worldwide (WHO, 2013). The findings revealed that the 49% of the respondents eat thrice a day, 65% of the respondents take carbonated drinks thrice in a day, 80% of respondents takes alcohol/stimulating drinks once in a day, 76% of respondent eat their breakfast before 1l am, 71%% of the respondents eat their lunch between 1-3pm, 72% eat dinner between 6-9pm, 51% buy their breakfast from vendors, 40% take snacks sometimes and 72% replace lunch with snacks. As found out from the study on food purchase from vendors, this might be as a result of convenience, affordability, cultural significance, economic opportunities among others ; whereas this might negatively impact the health of adolescents by increasing the risk of foodborne illnesses like typhoid fever, salmonellosis, and E- coli infections, unhealthy eating habits and increase in the like hood of overconsumption as fast food companies target adolescents with aggressive marketing strategies, promoting unhealthy food choices among them. Furthermore, in a systematic mapping review on factors influencing dietary behaviors in Africa, Ose- Kwasi, Holsworth, Pradeilles, Mohamoud and Mogo (2020) highlighted the importance of social environment and family influences in adolescents' food choices and consumption. In a nutshell, family and friends can encourage both healthy and unhealthy eating habits which may impact their health.

The findings also revealed that 73.4% of the respondents do not skip any meal, 92.4% of the respondents eat lunch, 97.6% of the respondents eat dinner, 63.7% buy meals from vendors, 92.8% of the respondents do not eat snacks between meals, 75.8% of the respondents replace main meal with snacks, 92.4% of the respondents take carbonated/soft drinks, 74.7% of the respondents do not take alcoholic/soft drinks. The classification of food according to Monteiro, Cannon, Moubarac, Levy,Louzada and Jaime (2019) is based on their level of processing, including unprocessed or minimally processed foods (fruits, vegetables, whole grains), processed culinary ingredients(sugars, oils, salt), processed foods (canned goods, bread) and ultra-processed foods(packaged snacks, frozen meals). The classification of food into groups can differ depending on the system used, but most systems categorize foods based on the origin and nutritional function. However, from the findings from the study, a higher percentage of respondents replaced main meal with snacks; this could be dangerous to their health because snacks often lack the balanced mix of macronutrients and micronutrients found

in main meals. This can lead to nutrients deficiencies over time, weight gain or difficulty losing weight, potentially leading to constipation or gastrointestinal issues among others. In addition to the findings from this study where 92.4% consume carbonated drinks; this can lead to overweight and obesity. The prevalence of overweight and obesity is increasing rapidly at epidemic levels in all ages globally and was found to be 10.2% and found geographical and socio-economic inequalities in the distribution of overweight/obesity among adolescents in Nigeria. (Adeleye, Nafisat and Olatunde, 2024). Adequate nutrients intake during adolescence is very important for many reasons. Increased nutritional needs at this juncture relate to the fact that adolescents gain up to 50% of their adult weight, more than 20% of their adult height and 50% of their adult skeletal mass during this period. Hence, adolescents need more nutrients than adults because they gain at least 40% of their adult weight during adolescence period. (Zorah, Anoosh and Zulfiqar, 2017). The adolescents therefore face series of serious nutritional challenges which would impact this rapid growth spurt as well as their health as adults. However, adolescents may face social and cultural barriers that limit their access to health care and other services such as stigma, discrimination, or lack of awareness about available resources.

Conclusion

Based on the findings of the study. it is therefore concluded that the socio-cultural influences do not determine adolescent's diet and physical activity. More so, adolescents' food choices have significant impact on their body shape. The type of food adolescents consumed determines the variance in the body shape of adolescents.

Recommendations

Based on the research findings, the following are recommended:

1. Parents and guardians should be engaged in nutrition education and meal planning.
2. Adolescents should be educated about healthy eating behaviors and incorporate courses on healthy lifestyle and nutrition across all education levels.
3. Provision of a 'healthy' cafeteria where healthy foods are sold at cheap and affordable rates to students.
4. Mass media should be used to sensitize parents of both negative and positive effect of adequate consumption of balance diet among adolescents.
5. Body positivity and self-esteem discussions should be integrated into health curricula in schools.

References

Adeleye,A.A.,Nafisat,O. &Olatunde,L.(2024). Overweight & Obesity Among Female Adolescents in Nigeria; An Emerging, but Under-reported Epidemic. BMC Women's Health,2024:24:302.doi.10.1186/s12905-024-03146-4

Clennan,M.K., Carucci, D.S.,Alert,M.D., Collins, S., Ettzel, E.N., LaRoche, A., Leeder, M.I. & Saab,P.G.(2019). Recent Advances in Applying Identity and Society Awareness to Virtual Learning.doi: 10.4018/978-1-5225-9679-0.ch008

Demory-Luce,D., & Motil,K.J.(2023).Adolescent Eating Habits. The Bogalusa Heart Study. *American Journal of Clinical Nutrition, 80(20), 354-360.*

Dubois,L.,Bedard,B., & Goulet,D.(2022). Eating Behaviors, Dietary Patterns and Weight Status in Emerging Adulthood and Longitudinal Associations with Eating Behaviors in Early Childhood. *International J. Behav. Nutr Phys Act 19, 139. https://doi.org/10.1186/s12966-022-01376-z*

Dunford,E.K.,Miles,D.R.,Popkin,B. & Shuwen, N.G.(2021). Whole Grain and Refined Grains: An Examination of US Household Grocery Stores Purchases. *Journal of Nutrition;152(2): 550-558.doi:1093/jn/nxab382.*

Glanz,K.(2015). Healthy Nutrition Environments: Concepts and Measures. *American Journal of Health Promotion.29(5):e1-e13.*

Monteiro,G., Canon,G.,Moubarac,J.C.,Levy,R.B., Louzada,M.L. & Jaime,P.C. (2019).NOVA: A Star Shines Bright in the Classification of Foods. *Public Health Nutrition Journal,22(1):3-6*

Omobuwa,O., Alebiosu,C.O.,Olajide, F.O., & Adebimpe, W.O.(2014). Assessment of Nutritional Status of in-school adolescents in Ibadan, Nigeria. *South African Family Practice,56(4), 246-250.*

Osei-Kwasi,H.A., Mohindra,A., Booth,A.,Laar,A.,Wanjohi,M., Graham,F., Pradeilles.R., Cohen,E.,& Holdsworth,M.(2020). Factors Influencing Dietary Behaviors in Urban Food Environments in Africa: A systematic mapping review. *Public Health Nutrition, 23(14),2584-2601.http://doi.org/10.1017/s1368980019005305.*

Zohra, L., Anoosh,M. & Zulfiqar,B.(2017). Nutrition in Middle Childhood and Adolescence. National Library of Medicine. 3rd Edition.

DIGITAL LITERACY AND THE ENHANCEMENT OF FOOD SAFETY EDUCATION IN TECHNICAL SCHOOLS IN RIVERS STATE: A CASE OF FEDERAL COLLEGE OF EDUCATION, TECHNICAL, OMOKU

Dibia-Emmanuel, Nkasimobu, C. Ph.D
Department of Home Economics, Hospitality & Tourism,
Ignatius Ajuru University of Education, Port Harcourt
Email: dibiaemmanuelkasy@gmail.com

Abstract

This study investigated the relationship between digital literacy and the enhancement of food safety education in technical schools, focusing on the Federal College of Education (Technical), Omoku, Rivers State, Nigeria. The study was motivated by the increasing need for digital transformation in education, particularly in technical and vocational learning where practical knowledge is essential. Using a descriptive survey design, data were collected from 200 respondents comprising 150 students and 50 lecturers. A structured questionnaire was employed to assess the level of digital literacy, utilization of digital tools in food safety education, and perceived learning outcomes. Descriptive statistics, including mean and standard deviation, were used to analyze responses, while Pearson's correlation was employed to test the relationship between digital tool use and educational outcomes. The results revealed a strong positive correlation ($r = 0.721$, $p < 0.001$), indicating that increased use of digital tools significantly enhances students' understanding and performance in food safety education. However, challenges such as poor internet connectivity, limited access to devices, lack of technical support, and inadequate teacher training were identified as barriers to effective digital integration. The study concludes that digital literacy is a critical enabler of improved food safety education outcomes. It recommends investment in ICT infrastructure, integration of digital tools into the curriculum, regular training for educators, and supportive institutional policies. These measures will ensure that technical colleges are well-positioned to produce graduates equipped with both digital competence and food safety skills necessary for the 21st-century workforce.

Keywords: Digital Literacy, Food Safety Education, Technical Schools, Educational Technology, Federal College of Education (Technical) Omoku, Rivers State, digital learning, food hygiene.

Introduction

Food safety education plays a pivotal role in safeguarding public health by equipping individuals with the knowledge and skills necessary to prevent foodborne illnesses and ensure the hygienic handling, preparation, and storage of food. In an era where food-related diseases remain a significant global concern, particularly in developing nations, food safety training is essential in reducing health risks and promoting sustainable food practices (World Health Organization [WHO], 2020). Educational institutions, especially technical and vocational schools, are critical platforms for delivering this training as they prepare students for practical roles in food production, catering, and hospitality sectors. By instilling safe food handling habits early, food safety education helps in building a well-informed workforce capable of protecting consumers and maintaining industry standards (Olumakaiye & Ajayi, 2016).

The integration of digital tools into education has transformed the delivery of knowledge, offering more interactive, flexible, and efficient modes of instruction. Digital technologies such as online modules, video tutorials, virtual simulations, and mobile learning applications have made learning more accessible and engaging, especially for practical subjects like food safety (Dede, 2010). These tools support personalized learning, facilitate real-time feedback, and provide diverse multimedia content that enhances understanding and retention. In the context of food safety, digital platforms can simulate kitchen environments, demonstrate food contamination processes, and offer up-to-date regulatory guidelines—thereby enriching both theoretical and practical learning experiences (Adekunle & Oloruntoba, 2014).

Current trends indicate a growing level of digital literacy among students and teachers in tertiary institutions in Nigeria, driven by increased access to smartphones, the internet, and government-supported ICT initiatives in education (Nwachukwu & Asomugha, 2021). However, disparities in the depth of digital skills between students and instructors remain, often due to limited training opportunities and infrastructural challenges. While students are often more adept at using digital tools for informal learning and communication, many teachers face difficulties in integrating technology into their instructional practices due to insufficient support and resistance to change (Olibie, 2015). Bridging this gap is necessary to fully exploit the potential of digital tools in educational environments.

The relevance of digital literacy in technical and vocational education cannot be overemphasized. As these institutions focus on skill acquisition and hands-on learning, incorporating digital competencies alongside vocational training ensures that graduates are not only technically proficient but also adaptable to the digital demands of modern workplaces (Federal Ministry of Education, 2020). In food safety education, this dual focus enables learners to access current information, adhere to evolving food regulations, and utilize digital monitoring tools effectively. For a technical institution like the Federal College of Education (Technical), Omoku, embracing digital literacy in food safety instruction is key to producing well-rounded professionals capable of responding to the challenges and innovations in the food sector.

Statement of the Problem

Food safety remains a major public health concern globally, with developing countries like Nigeria experiencing high incidences of foodborne illnesses due to poor food handling practices and inadequate hygiene standards. In technical institutions such as the Federal College of Education (Technical), Omoku, where students are trained in food-related disciplines, the importance of proper food safety education cannot be overemphasized. However, despite the critical role of food safety training in preparing students for professional food service and production environments, there remains a significant gap in students' food safety knowledge. This gap is often attributed to the limited use of modern digital technologies that can enhance learning and comprehension of food safety practices.

One of the primary challenges is poor digital engagement among both educators and students. Many instructors continue to rely heavily on traditional teaching methods such as lectures and printed notes, which may not sufficiently convey the practical and dynamic nature of food safety education. This lack of engagement with digital tools – such as instructional videos, virtual simulations, online assessments, and food safety mobile applications – limits students' exposure to real-world scenarios and current global best practices. Consequently, learners may graduate without adequate preparedness to handle food safely in increasingly digital and fast-evolving work environments.

Additionally, the low integration of digital resources into the curriculum further compounds the problem. Despite the growing emphasis on ICT in education, many technical colleges have not effectively embedded digital literacy or digital tools into food safety instruction.

Infrastructure deficits, limited access to devices, inadequate teacher training, and absence of institutional policies promoting digital learning contribute to this shortfall. As a result, students miss out on the benefits of engaging, flexible, and current digital learning methods that could significantly improve their understanding and application of food safety principles.

This study, therefore, seeks to investigate how digital literacy and the use of digital tools influence food safety education in technical schools, using the Federal College of Education (Technical), Omoku, as a case study. It aims to identify the extent to which poor digital engagement and insufficient curriculum integration of digital resources hinder effective food safety instruction and student preparedness.

Objectives of the Study

The main purpose of the study is to examine digital literacy and the enhancement of food safety education in technical schools in Rivers State using the Federal College of Education, Technical, Omoku as case study. The specific objectives are as follows:

1. To assess the level of digital literacy among food safety educators and students
2. To examine how digital tools are used in food safety instruction
3. To evaluate the effectiveness of digital platforms in enhancing food safety learning outcomes, and
4. To identify challenges and opportunities in using digital technology in technical school settings

Research Questions

The study was guided by the following research questions:

1. What is the level of digital literacy among food safety educators and students?
2. How are digital tools being utilized in food safety education?
3. What are the impacts of digital literacy on students' understanding of food safety?
4. What challenges are faced in implementing digital tools in food safety education?

Literature Review

Concept of Digital Literacy

Digital literacy is the ability to locate, evaluate, use, and create information using digital technology. It encompasses a range of skills including internet navigation, use of digital communication tools, data analysis, and digital content creation. As defined by Gilster (1997), digital literacy is not just about technical competence but also about understanding and using information from digital sources effectively. Eshet-Alkalai (2004) expanded this view by identifying key components such as photo-visual literacy, information literacy, and socio-emotional literacy, emphasizing that digital literacy is both cognitive and technical.

In the context of education, digital literacy is foundational to student learning and engagement in a digital age. It enables learners to interact with digital content, participate in virtual learning environments, and access online academic resources (Ng, 2012). The increasing integration of technology in education systems globally has made digital literacy a key competency for both teachers and students, influencing instructional design, curriculum development, and assessment strategies.

Overview of Food Safety Education

Food safety education involves teaching the principles and practices necessary to ensure that food is handled, prepared, and stored in ways that prevent foodborne illnesses. According to the World Health Organization (WHO, 2020), food safety knowledge is critical for reducing the burden of food-related diseases, especially in low- and middle-income countries where hygiene infrastructure is often lacking.

In educational settings, especially in technical and vocational institutions, food safety education is part of the broader curriculum in Home Economics, Hospitality, and Food Science programs. It includes modules on personal hygiene, kitchen sanitation, cross-

contamination, temperature control, and foodborne pathogens. The goal is to prepare learners for safe food handling in domestic and commercial contexts (Soon *et al.*, 2012). Effective food safety education relies heavily on practical, hands-on learning as well as conceptual understanding, making it a field that can significantly benefit from the integration of digital learning tools.

Integration of Digital Tools in Technical Education

Technical and vocational education and training (TVET) institutions are increasingly embracing digital tools to modernize instructional delivery and improve learning outcomes. The integration of Information and Communication Technologies (ICT) in technical education supports both theoretical and practical learning by providing simulations, instructional videos, e-learning platforms, and digital assessment systems (UNESCO, 2015). These tools enhance learner engagement, promote self-paced learning, and simulate real-world tasks that prepare students for employment in technology-driven industries.

However, the adoption of digital tools in Nigerian technical schools remains limited due to infrastructural constraints, poor internet connectivity, lack of digital skills among teachers, and insufficient policy implementation (Adesina & Odumuh, 2020). For example, many institutions still lack interactive smart boards, virtual labs, or adequate training for educators on e-pedagogy. The successful integration of digital tools depends not only on access to technology but also on supportive institutional frameworks and teacher readiness.

Empirical Studies Linking Digital Literacy and Education Outcomes

Several empirical studies have highlighted the positive relationship between digital literacy and educational outcomes. A study by Hatlevik et al. (2015) found that students with higher levels of digital competence performed better academically, particularly in subjects that required critical thinking and information synthesis. Similarly, Ng (2012) demonstrated that digital literacy enhances student autonomy, motivation, and engagement in online learning environments.

In the Nigerian context, Nwachukwu and Asomugha (2021) examined tertiary institutions and discovered that digital literacy significantly influenced students' ability to conduct research, complete assignments, and engage with multimedia instructional content. The study also revealed a digital gap between students and teachers, with students generally being more digitally adept than their instructors. This gap highlights the need for targeted training for educators to maximize the benefits of digital learning tools.

Additionally, Olufemi and Yusuf (2016) showed that the integration of ICT tools in teaching improved students' understanding and retention of vocational and technical subjects. The study emphasized that when learners are digitally literate, they are more likely to explore supplementary resources and adopt self-directed learning approaches that improve academic performance.

Theoretical Framework

Constructivist Learning Theory

The Constructivist Learning Theory posits that learners actively construct knowledge and meaning from their experiences rather than passively receiving information from the environment or the teacher. Rooted in the works of scholars like Jean Piaget and Lev Vygotsky, this theory emphasizes that learning is most effective when learners are engaged in authentic tasks, problem-solving, and collaborative activities that relate to real-world contexts (Piaget, 1976; Vygotsky, 1978).

Constructivism asserts that learning occurs when students interact with content, tools, instructors, and peers in ways that encourage critical thinking, reflection, and application. According to Vygotsky’s social constructivism, cognitive development is enhanced through

guided interaction with more knowledgeable others, including teachers and digital technologies that scaffold understanding. The theory is appropriate for this study in that constructivism aligns with the study's focus on digital literacy, as digital tools inherently support active, participatory learning. Through videos, simulations, interactive modules, and real-time feedback, students can construct knowledge about food safety by exploring, manipulating, and experimenting with digital content. These experiences move learners beyond rote memorization toward deeper understanding, which is the central tenet of constructivist learning (Jonassen, 1999).

Food safety is a practical subject requiring contextual understanding – handling food safely, preventing contamination, and adhering to hygiene protocols. Constructivist theory supports learning by doing, encouraging students to engage in real-world or simulated kitchen scenarios that reinforce safety principles. Digital technologies such as virtual reality or interactive case studies provide authentic contexts that allow learners to apply concepts, assess risks, and solve problems, in line with constructivist pedagogy. Constructivism promotes learner autonomy and responsibility, making it particularly suitable for technical and vocational education, where self-directed learning and hands-on skills are essential. With digital literacy skills, students can explore food safety standards, international best practices, and new food technologies independently. This supports technical institutions' goals of producing competent, self-reliant graduates (UNESCO, 2015).

Methodology

Research Design: This study adopted a descriptive survey research design. The descriptive survey method is suitable for collecting, analyzing, and interpreting data from a sample of respondents in a natural setting without manipulation of variables. This design was appropriate for assessing the current level of digital literacy among students and teachers, the extent to which digital tools are integrated into food safety education, and their perceived impact on learning outcomes in the selected technical college. According to Nworgu (2015), the survey method is ideal when the goal is to obtain data on opinions, behaviors, or characteristics of a population at a specific time.

Area of the Study: The study is situated in Federal College of Education (Technical), Omoku, located in Rivers State, Nigeria. This institution was selected due to its focus on technical and vocational education, including programs in Home Economics and Hospitality, which directly involve food safety instruction. The college offers a rich setting for exploring how digital literacy intersects with vocational training in food safety.

Population of the Study: The population of this study comprises all students and lecturers involved in food and nutrition-related courses within the School of Vocational and Technical Education at FCE (Technical), Omoku. This includes Home Economics students and staff, Hospitality Management students, and those enrolled in or teaching food safety and handling courses. The total estimated population is approximately 450 individuals (400 students and 50 lecturers), based on institutional records.

Sample and Sampling Technique: The study sample was 210 respondents (150 students and 50 lecturers). A multi-stage sampling technique was used to select participants for the study. In stage one, the purposive sampling was used to select relevant departments (Home Economics, Hospitality, and Food Science units). In stage two, stratified random sampling was used to ensure equal representation of both students and lecturers. In the third stage, simple random sampling was used to select the final participants from each stratum.

Yamane's formula for determining sample size (Yamane, 1967) was used to determine the sample size.

Instrumentation and Method of Data Collection: The main instrument for data collection was a structured questionnaire designed by the researcher and validated by experts in education and food science. The questionnaire was divided into four sections bearing on the research questions. The questionnaire used Likert-scale items (Strongly Agree to Strongly Disagree) to gauge perceptions, as well as closed-ended and a few open-ended questions to allow for more nuanced responses.

Data was collected through physical administration of questionnaires, supported by digital formats (Google Forms) for respondents who preferred online access. The researcher, with the assistance of trained research assistants, distributed and retrieved the questionnaires over a period of two weeks.

Method of Data Analysis: Data collected were coded and analyzed using descriptive and inferential statistics with the help of Statistical Package for Social Sciences (SPSS), version 26. The methods include: descriptive statistics – mean and standard – to summarize respondents' responses, Pearson's correlation to examine relationships between digital tool use and educational outcomes in food safety. Findings were presented using tables.

Results

The results are presented in the following tables:

Research Question 1: What is the level of digital literacy among food safety educators and students?

Table 1: Mean and standard deviation of respondents on the level of digital literacy among food safety educators and students

S/N		(n-150) Students			(n-50) Lecturers		
	Items:	$\overline{X}$	**SD**	**RMK**	$\overline{X}$	**SD**	**RMK**
1.	I can effectively use Microsoft Word, Excel, and PowerPoint	3.85	0.94	A	4.40	0.72	A
2.	I can browse the internet to find relevant educational materials	4.20	0.80	A	4.50	0.60	A
3.	I know how to use e-learning platforms like Google Classroom or Moodle	3.50	1.10	A	3.90	0.95	A
4.	I can assess the credibility of online food safety information	3.30	1.00	A	4.10	0.85	A
5.	I use online videos and simulations for learning food safety skills	3.75	0.98	A	3.60	1.05	A
6.	I can communicate using emails and messaging apps for academic work	4.10	0.85	A	4.20	0.80	A
7.	I can participate in online forums and group Discussions	3.40	1.12	A	3.60	0.90	A
8.	I have access to a personal device (laptop/ smartphone) for digital use	4.30	0.75	A	4.10	0.88	A
9.	I regularly use digital tools in classroom or practical sessions	3.25	1.05	A	3.40	0.95	A
10.	I have received formal training in digital literacy	2.90	1.15	A	3.20	1.00	A

Key: $\overline{X}$ = Mean score; *A (Agree) = ≥ 3.00; n=sample*
Mean is on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree)

Table 1 showed the mean and standard deviation of respondents on the level of digital literacy among food safety educators and students. Items with mean ≥ 4.0 suggest high agreement and thus higher perceived digital literacy. Items with mean ≤ 3.0 suggest moderate to low digital literacy, indicating potential gaps. Students rated lower than lecturers in digital credibility (Item 4) and formal training (Item 10). Both groups scored relatively high on internet use (Item 2) and access to digital devices (Item 8). Standard deviations (SD) indicate moderate variability, with students showing more diverse responses (higher SD) on some items.
Research Question 2: How are digital tools being utilized in food safety education?
Table 2: Mean and standard deviation of respondents on digital tools being utilized in food safety education

S/N		(n-150) Students			(n-50) Lecturers		
	Items:	$\overline{X}$	**SD**	**RMK**	$\overline{X}$	**SD**	**RMK**
1.	Multimedia presentations (e.g., PowerPoint) are used during food safety lessons	3.90	0.95	A	4.20	0.85	A
2.	I use video demonstrations or YouTube clips for learning/teaching food safety skills	3.80	1.00	A	1.10	3.50	A
3.	Food safety simulations or animations are used in practical sessions	3.20	1.10	A	3.50	1.05	A
4.	We use online platforms (e.g., Google Classroom, Zoom) for food safety instruction	3.10	1.20	A	3.60	1.00	A
5.	E-books or online manuals are available for food safety topics	3.50	1.05	A	3.70	0.95	A
6.	Mobile apps are used to demonstrate hygiene and food handling procedures	2.80	1.15	A	3.20	1.10	A
7.	Teachers share digital handouts and lecture materials online	3.60	1.00	A	3.90	0.85	A
8.	Digital quizzes or tests are used to assess food safety knowledge	3.30	1.10	A	3.60	1.00	A
9.	Students are encouraged to conduct online research on food safety regulations	4.00	0.85	A	4.20	0.75	A
10.	Learning Management Systems (LMS) are integrated into food safety teaching	2.90	1.20	A	3.10	1.15	A

Key: $\overline{X}$ = Mean score; *A (Agree) = ≥ 3.00; n=sample*
Mean is on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree)

Table 2 showed the mean and standard deviation of respondents on digital tools being utilized in food safety education. The table showed that high mean scores (≥ 4.0) on Items 1, 2, and 9 show strong use of multimedia presentations, videos, and internet research. Moderate utilization is observed in Items 3–5 and 7–8 (means between 3.3–3.9). Low mean scores (≤ 3.0) for Items 6 and 10 suggest limited use of mobile apps and formal LMS platforms in food safety education. Lecturers generally report slightly higher usage of digital tools than

students, suggesting awareness or intention, but possibly a gap in student access or interaction.

Research Question 3: What are the impacts of digital literacy on students' understanding of food safety?

Table 3: Mean and standard deviation of respondents on the impacts of digital literacy on students' understanding of food safety

S/N	(n-150) Students			(n-50) Lecturers		
Items:	$\overline{X}$	SD	RMK	$\overline{X}$	SD	RMK
1. Digital literacy has improved my ability to identify food safety hazards	3.90	0.90	A	4.30	0.75	A
2. I understand food hygiene better through the use of digital learning tools	4.10	0.85	A	4.20	0.80	A
3. Digital tools have helped me apply theoretical food safety knowledge in practice	3.75	1.00	A	4.00	0.90	A
4. My digital literacy helps me to easily access current food safety standards and guidelines	4.00	0.95	A	4.30	0.70	A
5. The use of digital videos and simulations has enhanced my food safety learning experience	3.85	1.00	A	4.10	0.85	A
6. I retain more information about food safety when digital tools are used	3.70	0.98	A	3.90	0.95	A
7. Digital resources encourage me to research food safety topics independently	4.20	0.80	A	4.40	0.70	A
8. My performance in food safety assessments has improved due to digital learning support	3.60	1.05	A	3.80	0.95	A

Key: $\overline{X}$ = Mean score; ***A (Agree) = ≥ 3.00; n=sample***

Mean is on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree)

Table 3 showed the mean and standard deviation of respondents on the impacts of digital literacy on students' understanding of food safety. The table showed that both students and lecturers agree that digital literacy has a positive impact on understanding food safety, with most mean scores between 3.60 and 4.40. Highest agreement from both groups is seen in: Item 7 (Independent research using digital tools); Item 2 (Understanding hygiene through digital tools) and Item 4 (Access to updated food safety information). Standard deviations show a moderate variability among students, with lecturers' responses more consistent.

Research Question 4: What challenges are faced in implementing digital tools in food safety education?

Table 4.4: Mean and standard deviation of respondents on the challenges are faced in implementing digital tools in food safety education

S/N	(n-150) Students	(n-50) Lecturers

Items:	$\overline{X}$	SD	RMK	$\overline{X}$	SD	RMK
1. Poor internet connectivity limits the use of digital tools in learning	4.30	0.85	A	4.40	0.75	A
2. There is insufficient access to digital devices like laptops and smartphones	3.90	1.00	A	4.10	0.95	A
3. Lack of digital training among teachers affects classroom integration of digital tools	3.80	1.05	A	4.50	0.70	A
4. Technical support and ICT maintenance are Inadequate	3.75	1.10	A	4.20	0.80	A
5. The college lacks a clear policy or curriculum framework for digital education	3.60	1.15	A	4.00	0.90	A
6. Power supply interruptions hinder the effective use of digital tools	4.20	0.90	A	4.30	0.85	A
7. There is low motivation or interest among students to use digital learning tools 3.40	1.20	A	3.20	1.15	A	

Key: $\overline{X}$ = Mean score; ***A (Agree) = ≥ 3.00; n=sample***
Mean is on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree)

Table 4.4 showed mean and standard deviation of respondents on the challenges are faced in implementing digital tools in food safety education. Internet connectivity, power supply, and lack of digital skills among teachers are the top challenges (mean ≥ 4.2). Students report slightly lower concern than lecturers on teacher digital competence and institutional policy gaps. Low student motivation scored the lowest mean, indicating it may not be a major perceived barrier. Standard deviations indicate greater variability in student responses, suggesting mixed experiences with digital tool accessibility and infrastructure.

Table 5: Pearson's correlation on relationships between digital tool use and educational outcomes in food safety

Respondent	Digital Tool Use	Educational Outcomes
1.	4.05	3.94
2.	3.73	3.81
3.	4.12	4.20
4.	4.56	4.45
5.	3.68	3.20

The Pearson's r = 0.721 indicates a strong positive correlation between digital tool use and educational outcomes. The p-value < 0.001 shows that the relationship is statistically significant. This means that increased use of digital tools (e.g., e-learning platforms, videos, simulations) is strongly associated with improved understanding and application of food safety concepts.

Discussion of Findings

The findings of this study provide compelling evidence that digital literacy and the effective use of digital tools significantly enhance educational outcomes in food safety education. Data from both students and lecturers revealed that the integration of digital resources – such as multimedia presentations, online videos, e-books, simulations, and learning management systems – contributed positively to learners' comprehension, retention, and application of food safety concepts. This aligns with the views of Ng (2012), who emphasized that digital literacy enables learners to access, evaluate, and apply information efficiently in real-world contexts, especially in scientific and technical subjects.

One of the most significant outcomes of the study was the result of the Pearson's correlation analysis, which showed a strong positive relationship ($r = 0.721$, $p < 0.001$) between the use of digital tools and educational outcomes. This indicates that as the level of engagement with digital learning tools increases, so does the learner's performance and understanding of food safety principles. These findings are consistent with Hatlevik et al. (2015), who reported that students with higher digital competence tend to perform better in subjects requiring applied knowledge and critical thinking.

Participants, particularly students, acknowledged that digital tools made abstract food safety concepts more concrete. Video demonstrations, simulations, and online forums allowed for self-paced, interactive learning experiences that fostered deeper understanding. This is supported by constructivist learning theory, which posits that learners actively construct knowledge through interaction with learning materials and their environment (Brooks & Brooks, 1999). Moreover, the availability of up-to-date digital resources helped students and lecturers remain informed about current food safety standards, hygiene practices, and technological innovations in food processing and storage (World Health Organization, 2020).

Despite the positive outlook, the study also identified notable challenges hindering the full implementation of digital tools. These included poor internet connectivity, limited access to digital devices, inadequate ICT support, and a lack of institutional policy frameworks for integrating digital learning into the curriculum. Students and lecturers alike expressed concerns over frequent power outages and low levels of institutional investment in digital infrastructure. These barriers are consistent with findings by Adesina and Odumuh (2020), who noted that Nigerian technical institutions often struggle with inadequate digital resources, which limit effective teaching and learning.

Another critical finding was the difference in digital readiness between students and lecturers. While many students exhibited a high level of comfort with digital tools, lecturers noted their own limited digital training as a barrier to fully leveraging technology in the classroom. This gap suggests the need for continuous professional development and institutional support to build educators' digital pedagogical capacity, as emphasized by UNESCO (2015) in its global recommendations for strengthening Technical and Vocational Education and Training (TVET).

In sum, this study confirms that digital literacy is a key enabler of effective food safety education in technical institutions. Students who are digitally literate and engaged with interactive learning tools demonstrate better understanding, increased motivation, and improved academic performance. However, achieving these outcomes at scale will require targeted investments in digital infrastructure, teacher training, and strategic policy integration to address existing systemic challenges.

Conclusion

This study examined the role of digital literacy in enhancing food safety education among students and lecturers at the Federal College of Education (Technical), Omoku. The findings revealed a strong, positive, and statistically significant relationship between the use of digital tools and educational outcomes in food safety. Respondents acknowledged that digital tools such as multimedia presentations, simulations, videos, and online resources greatly improved their understanding and application of food safety concepts.

Despite the evident benefits, several barriers hinder the effective implementation of digital tools. These include poor internet connectivity, inadequate access to devices, insufficient ICT infrastructure, lack of teacher training in digital pedagogy, and limited institutional support. The study underscores the need for technical institutions to modernize their teaching methods through investment in digital literacy and technology.

In conclusion, the integration of digital tools in technical education is not just beneficial but essential in equipping learners with practical knowledge and competence in food safety. Closing the digital divide among educators and learners will lead to more robust and effective vocational education outcomes.

Recommendations

Based on the findings, the following recommendations were made to the government and stakeholders:

1. Strengthening digital infrastructure by providing reliable internet, power supply, and digital devices for both students and educators.
2. Organizing regular training for lecturers on digital pedagogy and the use of e-learning tools.
3. Updating food safety curricula to include digital content and assessments.
4. Establishing institutional policies that promote and regulate the integration of digital tools in teaching and learning.
5. Partnership with tech providers, NGOs, and government agencies to support digital inclusion in technical education.

References

Adekunle, I. A., & Oloruntoba, E. O. (2014). Assessment of food safety knowledge and practices among food handlers in selected schools in Ibadan, Nigeria. *African Journal of Food, Agriculture, Nutrition and Development*, *14*(1), 8896–8908.

Adesina, A. S., & Odumuh, T. M. (2020). Constraints to digital integration in Nigerian TVET institutions. *Nigerian Journal of Educational Technology*, *5*(2), 102–110.

Brooks, J. G., & Brooks, M. G. (1999). *In search of understanding: The case for constructivist classrooms*. ASCD.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). SAGE Publications.

Dede, C. (2010). Comparing frameworks for 21st-century skills. In J. Bellanca & R. Brandt (Eds.), *21st Century Skills: Rethinking How Students Learn* (pp. 51–76). Solution Tree Press.

Eshet-Alkalai, Y. (2004). Digital literacy: A conceptual framework for survival skills in the digital era. *Journal of Educational Multimedia and Hypermedia, 13*(1), 93–106.

Federal Ministry of Education. (2020). *National Policy on ICT in Education*. Abuja: FME.

Gilster, P. (1997). *Digital literacy*. Wiley Computer Publishing.

Hatlevik, O. E., Throndsen, I., Loi, M., & Gudmundsdottir, G. B. (2015). Students' ICT self-efficacy and computer and information literacy: Determinants and relationships. *Computers & Education, 81,* 345–356.

Jonassen, D. H. (1999). Designing constructivist learning environments. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (Vol. II, pp. 215–239). Lawrence Erlbaum Associates.

Ng, W. (2012). Can we teach digital natives digital literacy? *Computers & Education, 59*(3), 1065– 1078.

Nunnally, J. C. (1978). *Psychometric theory* (2nd ed.). McGraw-Hill.

Nwachukwu, S. E., & Asomugha, C. N. (2021). Digital literacy and effective teaching in Nigerian tertiary institutions: Challenges and prospects. *Nigerian Journal of Educational Technology, 3*(1), 45–56.

Olibie, E. I. (2015). Adoption of e-learning technologies in Nigerian universities: Implications for improving quality of instruction and academic performance. *Africa Education Review, 12*(1), 120–135.

Olufemi, A. A., & Yusuf, M. O. (2016). Impact of ICT tools on teaching and learning of vocational and technical education in Nigeria. *Journal of Technical Education and Training, 8*(2), 55– 68.

Olumakaiye, M. F., & Ajayi, A. O. (2016). Food safety training improves knowledge and food handling practices of food handlers in selected institutions in south-west Nigeria. *Pakistan Journal of Nutrition*, *15*(3), 276–281.

Piaget, J. (1972). *The psychology of the child*. Basic Books.

Schunk, D. H. (2012). *Learning theories: An educational perspective* (6th ed.). Pearson.

Soon, J. M., Baines, R., & Seaman, P. (2012). Meta-analysis of food safety training on hand hygiene knowledge and attitudes among food handlers. *Journal of Food Protection, 75*(4), 793–804.

UNESCO. (2015). *Unleashing the potential: Transforming technical and vocational education and training*. Paris: UNESCO.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

World Health Organization (WHO). (2020). *Five keys to safer food manual*. https://www.who.int/publications/i/item/9789241594639

Yamane, T. (1967). *Statistics: An introductory analysis* (2nd ed.). Harper & Row.

ASSESSMENT OF STUDENTS ACADEMIC PERFORMANCE IN TECHNICAL DRAWING IN GOVERNMENT SCIENCE AND TECHNICAL COLLEGES YOBE STATE

Bala Adamu Wakili
Correspondence email address: waadba2006@yahoo, com
Electrical Department, School of Secondary Education (Technical)
Federal College of Education (Technical) Potiskum, Yobe State

Abstract
The study adopted a descriptive survey design with the used of questionnaire to elicit information from the respondents. The total population used for this study was 200 technical college teachers and students in Yobe State technical colleges. The instrument for data collection was questionnaire. The instrument sought information to identify the Assessment of students' academic performance in technical drawing in government science and technical colleges in Yobe State. The instrument was validated by three experts. The instrument was administered and retrieved personally by the researcher with the help of trained research assistant. All the 200 copies administered on the respondents in technical college in the state were returned showing 100% return rate. The data collected were analyzed using mean and standard deviation.
Keywords: Assessment, Students Academic Performance and Technical Drawing

Introduction
Technical education is an educational program that aims to provide students with practical skills and knowledge in various technical fields, including engineering, technology, and science (Makinde and Omotayo, 2017). The history of technical education can be traced back to the industrial revolution in Europe in the 18th and 19th centuries (Muthukumar, 2018).

Despite the benefits of technical education, the program faces several challenges in many countries, including inadequate funding, shortage of qualified teachers, inadequate curriculum development, and lack of equipment and facilities (Adeyemi et al., 2019; Oyelami and Akinrinmade, 2018). These challenges often result in poor quality technical education, which in turn affects the employability of graduates and the development of the economy (Kolawole, 2019).

Several initiatives have been introduced to improve technical education in many countries, including increased funding, capacity building for teachers, and curriculum development (Kolawole, 2019; Rao and Namrata, 2019). In Nigeria, the National Policy on Education recognizes the importance of technical education in the country's development and encourages the establishment of technical colleges and the promotion of technical education (Federal Republic of Nigeria, 2013). Technical education offers several benefits to students and society, including practical skills, career opportunities, economic development, and innovation (Aliyu, 2019 and Ogbazi, 2019). Technical education equips students with skills that are in demand in the labor market and provides them with the opportunity to become self-employed (Ogbazi, 2019). In addition, technical education plays a vital role in economic development by providing a skilled workforce, promoting entrepreneurship, and supporting innovation (Aliyu, 2019).

The future of work in Africa report by the World Bank highlights the potential of digital technologies in enhancing technical education and preparing students for the future workforce (World Bank, 2019). Digital technologies have the potential to improve the quality

of technical education, enhance student learning outcomes, and provide new opportunities for skills development (World Bank, 2019).

Technical colleges, also known as vocational colleges, are educational institutions that provide training and education in specific technical and vocational fields. The aim of technical colleges is to prepare students for employment in various industries and trades, such as construction, manufacturing, healthcare, and information technology. Technical colleges offer a practical, hands-on approach to learning, with a focus on developing the skills and knowledge necessary to succeed in a particular trade or industry.

In Yobe State, technical colleges are vocational education institutions that provide training in various technical and vocational fields. The colleges offer practical training and education to prepare students for employment in industries and other technical fields. The concept of technical colleges in Yobe State is an essential part of the state's education system, designed to address the skills gap and promote economic growth.

According to the Yobe State Ministry of Education, there are currently six technical colleges in the state. These colleges offer training in areas such as carpentry, plumbing, electrical installation, welding, and computer technology. The colleges aim to provide hands-on training to students, equipping them with practical skills that are relevant to the needs of industries and businesses.

The technical colleges in Yobe State are supported by various organizations, including the Federal Government of Nigeria, the United Nations Development Programme (UNDP), and the World Bank. These organizations provide financial and technical support to the colleges, helping to enhance the quality of education and training provided to students.

The technical colleges in Yobe State are part of the state's broader strategy to promote technical and vocational education in the country. Technical and vocational education is seen as a crucial element in addressing the skills gap and reducing unemployment in the country. The Nigerian government has been working to expand access to technical and vocational education, with a focus on increasing the number of technical colleges and improving the quality of education and training provided.

Technical drawing is a fundamental subject in technical education, and it plays a critical role in preparing students for technical and vocational careers. Technical drawing involves the use of graphical symbols and conventions to represent objects, structures, and systems accurately. Students who study technical drawing develop skills in visualization, interpretation, and communication, which are essential in engineering, architecture, and other technical fields.

In Nigeria, technical education is a critical component of the educational system, and it is intended to equip students with the necessary skills and knowledge to participate effectively in the country's technical and economic development. Technical education in Nigeria is offered at various levels, including primary, secondary, and tertiary levels, and it covers a broad range of fields, including agriculture, engineering, and technology.

Despite the importance of technical education in Nigeria, the quality of technical education has been a matter of concern. Technical education in Nigeria faces several challenges, including inadequate funding, lack of equipment and facilities, shortage of qualified teachers, and inadequate curriculum development (Adamu and Haruna, 2019). These challenges have led to a decline in the quality of technical education in Nigeria and a low level of preparedness among graduates of technical institutions.

One of the most common problems affecting the performance of technical drawing in technical colleges is a lack of adequate resources and materials. According to a study conducted by Remya and Thomas (2017), many technical colleges in India lack access to modern drafting tools and equipment, which can negatively impact the quality of technical

drawings produced by students. Additionally, a lack of trained instructors and limited instructional time can also hinder students' ability to develop their technical drawing skills.

Another issue that can affect the performance of technical drawing in technical colleges is a lack of emphasis on the importance of drafting skills in the curriculum. As noted by Mahadi and Akhtar (2016), some technical colleges in Bangladesh do not give enough attention to technical drawing in their programs, resulting in students not receiving adequate instruction or practice in this critical skill. This lack of emphasis can result in a lack of confidence and competence among students when it comes to producing technical drawings. Furthermore, a lack of understanding of the principles of technical drawing can also hinder students' performance. According to Okunola and Adeoye (2017), many students in technical colleges in Nigeria struggle with technical drawing because they do not have a solid foundation in the underlying principles of geometry and spatial visualization. Without a strong understanding of these fundamentals, students may struggle to produce accurate and detailed technical drawings.

Metacognitive strategies have also been found to have a significant impact on academic performance. Wu (2018) found that the use of metacognitive strategies such as self-monitoring and self-regulation were positively correlated with academic performance in a flipped classroom. In addition, Kramarski and Mizrachi (2019) found that the use of a cognitive tutor program significantly improved the academic performance of low-achieving students in mathematics.

Academic performance is a multifaceted construct that can be defined and measured in different ways. According to Gardner and Jewler (2019), academic performance is the extent to which students achieve the learning outcomes or objectives set by educational institutions. It is a product of a student's cognitive abilities, motivation, and study habits, as well as the quality of instruction they receive. In terms of measuring academic performance, grades and standardized test scores are commonly used indicators. However, these measures have been criticized for their limited ability to capture the full range of a student's abilities and knowledge (Hutchings et al., 2019). Other methods of assessment, such as portfolios, performance-based assessments, and self-evaluations, have been proposed as alternatives that can provide a more comprehensive and accurate picture of a student's academic performance.

Academic performance refers to a student's ability to learn and demonstrate knowledge, skills, and understanding in a formal educational setting (Ryan and Deci, 2020). It can be measured in various ways, including grades, test scores, and evaluations from teachers or professors. Academic performance is influenced by a variety of factors, including a student's intelligence, motivation, study habits, and the quality of instruction they receive (Ryan and Deci, 2020). Other factors that may impact academic performance include a student's socio-economic background, access to resources such as technology and textbooks, and their physical and mental health (Matsudaira *et al.,* 2020).

Statement of the Problem

In recent years, technical drawing has gained prominence as a crucial subject within the curriculum of government science and technical colleges in Yobe State. However, "Despite the implementation of technical drawing curriculum in government science and technical colleges in Yobe State, there remains a need to assess the factors influencing students' academic performance in this subject. This study aims to identify the challenges and variables impacting students' achievement in technical drawing, including teaching methods, resources, student engagement, and socio-economic factors, in order to propose effective strategies for enhancing academic performance." According to Adeyemi et al. (2019), technical drawing has been identified as one of the subjects that students in technical colleges

find difficult to comprehend. This may be due to several factors, including inadequate teaching materials, ineffective teaching methods, and lack of motivation among students. the quality of technical education in Yobe State has been a subject of debate, with some stakeholders expressing concerns about the level of training and preparedness of graduates from technical colleges. A study by Adamu and Haruna (2019) revealed that technical education in Yobe State faces several challenges, including inadequate funding, lack of equipment and facilities, and shortage of qualified teachers.

Purpose of the Study

The main purpose of the study is to

1. To evaluate the overall academic performance of technical drawing students in technical colleges in Yobe State.
2. To identify the strengths and weaknesses of students in technical drawing in Yobe State technical colleges.
3. To determine the factors that contribute to academic success or challenges in technical drawing in technical colleges in Yobe State.
4. To assess the effectiveness of the technical drawing curriculum and teaching methods used in Yobe State technical colleges.

Research Questions

The following research questions were formulated to guide the study:

1. What is the level of academic performance of students in technical drawing in selected government science and technical colleges in Yobe State?
2. What are the factors that influence the academic performance of students in technical drawing in government science and technical colleges in Yobe State?
3. What are the teaching and learning methods employed in teaching technical drawing in government science and technical colleges in Yobe State?
4. What are the challenges faced by teachers and students in teaching and learning technical drawing in government science and technical colleges in Yobe State?

Methodology

The study adopted a survey research design. A Survey research design is a quantitative research method that involves the collection of data from a sample of individuals through the use of questionnaires or interviews. The data collected is then analyzed to draw conclusions about a population of interest. According to Bryman and Bell (2019), survey research design is "a type of research design in which a sample of individuals is selected from a larger population and is asked to respond to a standardized set of questions. According to Babbie, (2016). Survey research design is a type of research method that involves collecting data from a sample of individuals through a standardized questionnaire or interview. According to Babbie (2016), survey research design is “a method of collecting data in which information is obtained from a sample of individuals through their responses to a standardized set of questions" The survey research design is suitable for this study since data will be collected from large number of population through questionnaire from technical drawing teachers and students on the assessment of student's academic performance in technical drawing in government science and technical college's in Yobe State.

This research work will carry out in Yobe State of Nigeria in Northeast geopolitical zone, Yobe State covers an Area of about 47,153 square kilometers. It shared an international border with republic of Niger to the North with latitude 14.0°N and longitude 8.5°E. Within the country, it shared borders with Jigawa State to the Northwest with latitude 12.5°N and longitude 9.5°E, Bauchi State to the West with latitude 11.5°N and longitude 10.5°E, Borno

State to the East with latitude 11.5°E and longitude 12.5°E as well as Gombe State to the South with latitude 10.5°N and longitude 11.5°E.

The state consist of three (3) educational zones; Damaturu zone (zone "A") comprised of GSTC Gujba, Potiskum zone (zone "B") comprised of GSTC Potiskum, GGSTC Potiskum and GSTC Damagum. And Nguru zone (zone "C") comprised of GSTC Gashua, GGSTC Dapchi, GSTC Nguru and GSTC Geidam respectively. Hence, there eight (8) Technical Colleges spread across the three (3) Educational Zones of the State.

The target population of this study consists of all two thousand eight hundred and sixty seven (2867) students/teachers enrolled in government science and technical colleges Yobe State.

Stratified random sampling techniques were used to select 200 students from government science and technical college Potiskum.

The instrument for data collection is structured questionnaire designed by the researcher title: Assessment of students' performance questionnaire (ASPQ). The questionnaire items were generated after extensive review of available literature on Assessment of Student's Academic Performance in Technical Drawing in Government Science and Technical Colleges Yobe State. The items in the questionnaires were organized in accordance with the research questions to guide the study.

The questionnaire was having one type of response scale; i.e the odd Likert scale to give the respondents the choice of responding neutrally. The odd likert scale category was based on 5 points rating scale with nominal values assigned.

Results and Analysis

Research Question 1: What is the level of academic performance of students in technical drawing in government science and technical colleges in Yobe State?

Data for answering this research question are presented in table 1 below.

Table 1: Mean responses of respondents' level of academic performance of students in technical drawing in government science and technical colleges in Yobe State

S/N	Item	$\bar{x}$	σ	Remarks
1	The academic performance of students in technical drawing at G.S.T.C Yobe State.	4.08	0.25	Agreed
2	The level of academic performance in technical drawing at G.S.T.C in Yobe State is commendable.	3.81	0.22	Agreed
3	Students at G.S.T.C in Yobe State demonstrate a high level of academic performance in technical drawing.	4.18	0.28	Agreed
4	The academic performance of students in technical drawing at G.S.T.C in Yobe State is above average.	3.61	0.17	Agreed
5	G.S.T.C in Yobe State has a strong record of academic excellence in technical drawing	3.95	0.24	Agreed

Data presented in Table 1 above shows that the respondents agreed on all items as level of academic performance of students in technical drawing in government science and technical colleges in Yobe State based on the means which range from 3.61 to 4.18. The standard deviation values range from 0.17 to 0.28 this show that the respondents are not far from each other on the responses.

Research Question 2: What are the factors that influence the academic performance of students in technical drawing in government science and technical colleges in Yobe State?

Data for answering this research question are presented in Table 2 below.

Table 2: Mean responses of respondents on factors that influence the academic performance of students in technical drawing in government science and technical colleges in Yobe State.

S/N	Items	$\bar{x}$	σ	Remarks
1	The availability of adequate learning resources positively impact academic performance in technical drawing at Yobe State Government Science and Technical Colleges.	4.3	0.28	Agreed
2	Technical expertise and instructional quality significantly influence the academic performance in technical drawing at Yobe State Government Science and Technical Colleges.	3.9	0.22	Agreed
3	Students' motivation and engagement play a crucial role in determining academic performance in technical drawing at Yobe State Government Science and Technical Colleges.	3.79	0.22	Agreed
4	Learning environment including classroom condition and facilities has a significant impact on the academic performance of students in technical drawing at G.S.T.C	3.78	0.22	Agreed
5	Parental involvement and support has a positive influence on the academic performance of students in technical drawing in Yobe State G.S.T.C	4.23	0.28	Agreed

Data presented in Table 2 above shows that the respondents agreed on all factors that influence the academic performance of students in technical drawing in government science and technical colleges in Yobe State based on the mean score which range from 3.78 to 4.3. the standard deviation shows that the respondents are close on their responses with values range from 0.22 to 0.28.

Research Question 3: What are the teaching and learning methods employed in teaching technical drawing in government science and technical colleges in Yobe State?
Data for answering this research question are presented in Table 3 below.
Table 3: Mean responses of respondents on the teaching and learning methods employed in teaching technical drawing in government science and technical colleges in Yobe State

S/N	Items	$\bar{x}$	σ	Remarks
1	Practical and hands-on teaching methods enhance technical drawing education.	4.64	0.33	Agreed
2	Interactive teaching approaches promote effective technical drawing instruction.	4.04	0.24	Agreed
3	Visual aids and demonstrations improve technical drawing learning outcomes.	3.91	0.22	Agreed
4	Incorporating real-world applications enhances technical drawing teaching effectiveness.	4.30	0.28	Agreed
5	Students centered teaching methods facilitate better understanding of technical drawing.	3.55	0.17	Agreed

Data presented in Table 3 above shows that the respondents agreed on all the teaching and learning methods employed in teaching technical drawing in government science and technical colleges in Yobe State. The Mean values range from 3.55 to 4.64 and standard deviation shows that the respondents are close on their responses.

Research Question 4: What are the challenges faced by teachers and students in teaching and learning technical drawing in government science and technical colleges in Yobe State?
Data for answering this research question are presented in Table 4 below.

Table 4: Mean responses of respondents on the challenges faced by teachers and students in teaching and learning technical drawing in government science and technical colleges in Yobe State

S/N	Items	$\bar{x}$	σ	Remarks
1	Limited access to technical drawing equipment hinders instruction.	3.66	0.20	Agreed
2	Inadequate teacher training affects technical drawing education quality.	4.17	0.26	Agreed
3	Insufficient time allocated for technical drawing instruction limits learning.	3.95	0.24	Agreed
4	Lack of student interest poses challenges in technical drawing.	4.23	0.28	Agreed
5	Limited classroom space impacts technical drawing learning environment.	4.18	0.26	Agreed

Data presented in Table 4 show that the respondents agreed on the challenges faced by teachers and students in teaching and learning technical drawing in government science and technical colleges in Yobe State based on the mean score which range from 3.66 to 4.23. and standard deviation 0.20 to 0.28. the standard deviation shows that the respondents are close on their responses.

Findings of the Study

From the data analysis of following findings were made, that;

4. The level of academic performance of students in technical drawing in government science and technical colleges in Yobe State is generally agreed upon by the respondents, with mean scores ranging from 3.61 to 4.18 and a standard deviation between 0.17 and 0.28.
5. The factors influencing the academic performance of students in technical drawing in government science and technical colleges in Yobe State are also agreed upon by the respondents, with mean scores ranging from 3.78 to 4.3 and a standard deviation between 0.22 and 0.28.
6. The teaching and learning methods employed in teaching technical drawing in government science and technical colleges in Yobe State are widely agreed upon by the respondents, with mean values ranging from 3.55 to 4.64 and a standard deviation indicating respondents are close in their responses.
7. The challenges faced by teachers and students in teaching and learning technical drawing in government science and technical colleges in Yobe State are acknowledged by the respondents, with mean scores ranging from 3.66 to 4.23 and a standard deviation between 0.20 and 0.28, suggesting respondents' responses are closely aligned.

Discussion of findings

The findings presented in Table 1 show the level of academic performance of students in technical drawing in government science and technical colleges in Yobe State. The respondents agreed with all the factors identified such as the academic performance of students is satisfactory, and level of academic performance in technical drawing is commendable also students demonstrate a high level of academic performance in technical

drawing so also students of government science and technical colleges has a strong record of academic excellence in technical drawing.

The findings in Table 2 indicate that the respondents agreed with the influencing the academic performance of students in technical drawing in government science and technical colleges in Yobe State, these influences include the availability of adequate learning positivity impacts academic performance, teachers expertise and instructional quality significantly influence the academic performance of students in technical drawing also students motivation and engagement play a crucial role in academic performance in technical drawing.

In Table 3, it was also found that the teaching methods employed in teaching technical drawing in government science and technical colleges in Yobe State. Some of these teaching methods include practical and hands-on teaching methods enhance technical drawing education, interactive teaching approaches promote effective technical drawing instruction and visual aids and demonstrations improve technical drawing teaching effectiveness also incorporating real-world applications enhances technical drawing teaching effectiveness so also student-centered teaching methods facilitate better understanding of technical drawing.

In Table 4, it was also found some of the challenges faced by teachers and students in teaching and learning technical drawing in Yobe State government science and technical amongst the challenges there is limited access to technical drawing equipment, inadequate teacher training affects technical drawing education quality and insufficient time allocated for technical drawing instruction limits learning also lack of student interest poses challenges in technical drawing and so also limited classroom space impacts technical drawing learning environment.

This chapter present the summary of the study, conclusion, recommendations and recommendation for further study.

Conclusion

From the result of this study it was discovered by the researcher that technical drawing in the government science and technical colleges in Yobe State Needed capacity building for effective teaching of technical drawing in government science and technical colleges in Yobe State planning instruction, implementing instruction, providing effective teaching and learning technical drawing, providing the qualify teachers for teaching technical drawing and provide the learning atmosphere. If the findings of this study is developed in to a capacity building programme for teachers of technical drawing students it will help them to overcome their inadequate in the teaching of technical drawing towards the realization of the approved objectives of the subject in government science and technical colleges in the area of the study.

Recommendations

Based on the findings of the study, the following recommendation were made:

3. Government should Invest in modern equipment for technical drawing education
4. Offer professional development for teachers to address challenges effectively.
5. Foster collaboration between schools and industry experts for comprehensive solutions.
6. Government should Update curriculum based on research findings for improved learning outcomes.

References

Adamu, M. A., & Haruna, B. S. (2019). Quality assurance in technical and vocational education in Yobe State, Nigeria. Journal of Education and Practice, 10(7), 32-40.

Adeyemi, T. O., & Adeyinka, A. A. (2016). Technical and vocational education in Nigeria: Issues, challenges and prospects. Journal of Technical Education and Training, 8(1), 15-23.

Adeyemi, T. O., Owoyemi, O. T., & Adeyanju, A. O. (2019). Challenges facing technical education in Nigeria. Journal of Technical Education and Training, 11(1), 51-60.

Aliyu, I. M., Gado, N., & Lawal, A. Y. (2019). An assessment of the role of technical and vocational education and training (TVET) in Nigeria's economic development. Journal of Technical Education and Training, 11(1), 1-10.

Aliyu, M. O. (2018). Innovative teaching methods in technical education for sustainable development. European Journal of Education Studies, 5(5), 218-229.

Federal Republic of Nigeria. (2013). National policy on education. Retrieved fromhttp://www.neco.gov.ng/national_policy_on_education.htm

Gardner, S. K., & Jewler, A. J. (2019). Understanding and measuring academic performance. In R. G. Bringle, J. M. Hatcher, & M. A. Jones (Eds.), International service learning: Engaging host communities (pp. 35-50). Routledge.

Garg, A., & Tewari, R. (2018). A review on engineering drawings and computer aided design. Materials Today: Proceedings, 5(2), 3839-3845.

Hutchings, P., Ciccone, A., Gamboa, V., O'Rourke, K., & Stein, S. (2019). Beyond grades: Alternative assessments that work. Jossey-Bass.

Ige, J. T., & Olorundare, A. S. (2021). Effects of problem-based learning and cooperative learning strategies on the academic performance of technical drawing students in technical colleges. Journal of Technical Education and Training, 13(1), 15-24.

Iyamu, E. O., & Ibhaze, A. A. (2020). Effects of animation technique on the achievement and retention of technical drawing concepts of technical college students in Edo State, Nigeria. Journal of Technical Education and Training, 12(1), 55-65.

Kolawole, E. B. (2019). The challenges and prospects of technical education in Nigeria. Journal of Technical Education and Training, 11(1), 11-24.

Mahadi, T. F., & Akhtar, N. (2016). An investigation into the teaching and learning of technical drawing in Bangladesh. International Journal of Education and Research, 4(2), 191-200.

Makinde, O. J., & Omotayo, T. O. (2017). Technical education in Nigeria: A tool for sustainable development. European Journal of Education Studies, 3(3), 193-205

Matsudaira, J. D., Harada, Y., Sato, T., Ogura, T., Wada, K., & Takahashi, S. (2020). A meta-analysis of the relationship between socioeconomic status and academic achievement in Japan. Japanese Psychological Research, 62(2), 155-167.

Muthukumar, S. (2018). Technical education and economic development: A review of literature. Journal of Technical Education and Training, 10(2), 29-38.

Ogbazi, J. I. (2019). Technical education: A panacea for unemployment and poverty reduction in Nigeria. Journal of Technical Education and Training, 11(1), 25-34.

Okunola, A. A., & Adeoye, A. O. (2017). Students' perception of difficulties in technical drawing: A case study of technical colleges in Lagos State, Nigeria. International Journal of Technical Research and Applications, 1(4), 49-55.

Oyelami, M. O., & Akinrinmade, O. J. (2018). Assessment of the relevance of technical education to Nigeria's industrial development. International Journal of Scientific and Research Publications, 8(2), 381-387.

Rao, K. V., & Namrata, S. (2019). Technical education in India: Challenges and opportunities. Journal of Technical Education and Training, 11(1), 35-50

Remya, V. M., & Thomas, S. (2017). A study on the status of technical drawing education in technical colleges in Kerala. International Journal of Engineering Technology Science and Research, 4(2),113-120.

Ryan, R. M., & Deci, E. L. (2020). Self-determination theory: Basic psychological needs in motivation, development, and wellness. Guilford Publications.

United Nations Development Programme. (2017). Technical and Vocational Education and Training (TVET) in Nigeria. Retrieved from https://www.ng.undp.org/content/nigeria/en/home/library/human_development/technical-and-vocational-education-and-training--tvet--in-nige.html

World Bank. (2019). The future of work in Africa: Harnessing the potential of digital technologies for all. Retrieved from

Wu, J., Li, Y., Xu, S., & Li, J. (2019). An online peer evaluation system for improving technical drawing skills. Journal of Educational Technology & Society, 22(4), 116-127.

Yobe State Ministry of Education. (n.d.). Technical Colleges. Retrieved from https://www.yobestate.gov.ng/ministries-departments-agencies/ministry-of-education/technical-colleges/

Yu, R., Wang, X., Zhang, L., & Guo, H. (2018). A review of research on geometric modeling of mechanical products. Journal of Mechanical Science and Technology, 32(2), 463-475.

PROJECT-BASED LEARNING CONCEPTUAL MODEL FOR NON-TECHNICAL SKILLS OF ELECTRICAL INSTALLATION AND MAINTENANCE WORK STUDENTS IN TECHNICAL COLLEGES IN NORTH-WEST, NIGERIA

Ibrahim, Y., Saba, T M., Owodunni A S. and Raymond E
Department of Industrial and Technology Education
School of Science and Technology Education
Federal University of Technology, Minna

Abstract

This study identified the non-technical skills and learning activities for inclusion in Project-Based Learning (PjBL) conceptual model for the integration of non-technical skills into the Electrical Installation and Maintenance Works (EIMW) programme in technical colleges in North-West Nigeria. The study was guided by two research questions and tested two corresponding null hypotheses. A Mixed Methods Research (MMR) design of the convergent parallel type was adopted, combining both quantitative and qualitative approaches to deepen understanding and ensure triangulation of findings. The population comprised 405 stakeholders, out of which 246 respondents participated in the study. Data were collected through a validated Non-Technical Skills Assessment Questionnaire (NSAQ) and a Focus Group Discussion (FGD) guide. The instruments were subjected to face and content validation by experts, and their reliability was confirmed using Cronbach's Alpha (0.82) and Cohen's Kappa (0.84), indicating high consistency and agreement. Quantitative data were analyzed using descriptive statistics (mean and standard deviation) and Analysis of Variance (ANOVA) at 0.05 significance level, while qualitative data were analyzed thematically. The findings of the study revealed that twenty key non-technical skills, including collaborative teamwork, leadership, digital literacy, AI skills, emotional intelligence, adaptability, and critical thinking, among others, are essential for inclusion in the proposed PjBL conceptual model (mean = 4.08 and SD = .68). Additionally, appropriate learning activities such as collaborative group projects, industry-based internships, and workplace simulations were identified for inclusion (mean = 4.09 and SD = .68), along with assessment strategies like peer assessment, role-play evaluations, and portfolio assessments (mean = 4.09 and SD = .67). There was no significant difference in the responses of School-Based SMEs, Industry-Based SMEs, and Employers of Labour across all components for inclusion in PjBL model (p < 0.05) Based on these findings, the study recommended, among others, that the National Board for Technical Education (NBTE) should revise the EIMW curriculum to formally integrate the identified non-technical skills through structured PjBL activities.

Key words: Project Base Learning, Non Technical skills, Electrical Installation and Maintenance Work

Introduction

Technological development in the workplace and industries has necessitated the need to equip students with essential workplace skills, making them adaptable to the present and envisaged future challenges. As new technologies are developed and implemented, employers require skilled technicians to operate and maintain sophisticated equipment and systems (Akyazi *et al*., 2020). The rapid pace of technological change has made it imperative for individuals to continuously update their technical skills to remain relevant in the labour market (Kim and Park, 2020). Technical Skills (TS) refer to applying theoretical knowledge to practical tasks. These skills are essential for successfully operating complex systems and equipment in industries (Sony and Naik, 2020). TS are the foundation of knowledge for

students to learn by listening to lectures and doing practical (Srivatanakul and Annansingh, 2022). These skills and knowledge distinctly define the focus of technical education, preparing students to become competent and professional technicians upon graduation from Technical Colleges. Mele *et al. (*2020) revealed that the technical collegue curriculum was designed to facilitate the acquisition of skills by the students in various trade areas, such as: Automobile trades, building and woodwork trades, business trades, computer trades, hospitality trades, textile trades and electrical/electronic trades among which are Electrical Installation and Maintenance Work (EIMW).

Electrical Installation and Maintenance Work (EIMW) is a vocational trade offered in Technical Colleges under the NTC curriculum. The goal of EIMW is to produce competent craftsmen with the knowledge and practical ability to carry out installation, maintenance, and repair of electrical systems in both domestic and industrial environments. The curriculum provides practical exposure to surface and conduit wiring, principles of electrical protection devices, and fault diagnosis. This practical emphasis ensures that students are adequately prepared to undertake real-life electrical tasks and develop job-relevant skills.

Skills refer to the abilities and competencies that individuals acquire to perform specific tasks or solve problems efficiently and effectively. In the context of vocational and technical education, these skills are generally classified into two broad categories: technical and non-technical skills. Technical skills are job-specific competencies that involve the practical application of knowledge to operate tools, machinery, and equipment or to complete specialized tasks. On the other hand, non-technical skills (NTS) are personal and interpersonal attributes that enable individuals to function well in social and professional environments. Non-technical skills are often referred to as transferable or soft skills because they can be applied across a wide range of occupations and industries, irrespective of specific technical backgrounds (Cobianchi *et al*., 2022).

Despite widespread acknowledgment of their importance, non-technical skills are frequently underemphasized in technical and vocational education, raising concerns about the overall readiness of graduates for real-world employment. While students may acquire high levels of technical proficiency, their inability to communicate effectively, lead teams, or manage time often limits their success in the workplace (Kövesi & Kálmán, 2020; O'Brien *et al*., 2021; Obioha and Sotshangane, 2022)). This imbalance between technical competence and non-technical readiness is particularly evident in the training of EIMW students, whose curriculum tends to focus heavily on technical content. This has necessitated a change in instructional approaches that integrate both skill domains to promote holistic student development such as Project-Based Learning where students learn by actively engaging in real-world and personally meaningful projects. The collaborative and student-centered approach makes PjBL particularly effective in cultivating non-technical skills for inclusion.

Non-technical skills for inclusion in the proposed PjBL conceptual model must be carefully selected to align with the expected industry standards for EIMW graduates. The success of any model depends on embedding competencies into authentic learning experiences, which naturally leads to the design of purposeful learning activities for inclusion which must be carefully designed to stimulate engagement, critical thinking, and the development of non-technical competencies.

By embedding assessment strategies, effective instructional techniques, implementation processes, development processes in a systemic framework, the PjBL model's outcomes can be validated and refined through feedback and evaluation by Subject Matter Experts (SMEs) which are highly knowledgeable professionals with expertise in electrical installation and maintenance work. The SMEs provide critical perspectives for developing a Project-Based Learning (PjBL) conceptual model tailored to enhance non-technical skills

among EIMW students, as well as meet the expectations of employers of labour such as electrical contractors, construction companies, manufacturers, and government agencies—now prioritize non-technical skills (NTS) alongside technical skills (TS) when hiring. Despite having strong technical capabilities, many Technical College graduates, particularly in Electrical Installation and Maintenance Work (EIMW), lack essential soft skills needed for workplace success (Ayodele *et al*., 2021; Muhd Khaizer *et al*., 2020; Noah & Abdul Aziz, 2020). This mismatch between graduate skills and industry demands has created pressure on Technical Colleges to produce more well-rounded craftsmen (Compagnucci & Spigarelli, 2020). The current EIMW curriculum falls short in addressing NTS, limiting students' employability and career growth. These concerns underscore the need for this study.

1.2 Statement of the Research Problem

In today's global economy, industries face intense competition, necessitating a workforce equipped with both technical and non-technical skills. Technical and Vocational Education and Training (TVET) programs are pivotal in preparing individuals for the workforce by providing practical skills, general education, and attitudes necessary for various occupations (Sharma *et al*., 2023). However, a critical issue persists: many graduates of TVET programs, particularly in EIMW, remain unemployed due to inadequate preparation for the demands of the 21st-century workplace (Rani, 2021). While technical skills are emphasized in TVET programs, non-technical skills such as communication, teamwork, problem-solving, and creative thinking are often overlooked. Employers have reported dissatisfaction with graduates' readiness for the workplace, noting that although graduates possess technical expertise, they lack the soft skills essential for solving problems and achieving occupational success (Alex *et al*., 2021; Munir, 2022). This misalignment between educational outcomes and industry needs highlights a gap in TVET curriculum design, particularly in the development of non-technical skills (Dogara *et al*., 2019; Jackson & Hancock, 2020). Thus, this study sought to address the challenge by developing a Project-Based Learning (PjBL) conceptual model tailored to enhance non-technical skills among EIMW students in Technical Colleges in North-West Nigeria.

Aim and Objectives of the Study

The study aimed at developing a PjBL conceptual model for non-technical skills for EIMW students in Technical Colleges in North-West, Nigeria. Specifically, the study sought to:

1. Identify the non-technical skills for inclusion in the proposed PjBL conceptual model of EIMW students in technical colleges in North-West Nigeria

2. Determine the learning activities for inclusion in the PjBL conceptual model for non-technical skills of EIMW students in technical colleges in North-West Nigeria.

Research Questions

1. What are the non-technical skills for inclusion in the proposed PjBL conceptual model of EIMW students in technical colleges in North-West Nigeria?

2. What are the learning activities for inclusion in the PjBL conceptual model for non-technical skills of EIMW students in technical colleges in North-West Nigeria?

Hypotheses

The following null hypotheses were tested at 0.5 level of significance to guide the study:

H_{O1}: There is no significant difference in the mean responses of School-Based SMEs, Industry-Based SMEs and Employers of Labour on the non-technical skills for inclusion in

the proposed PjBL conceptual model of EIMW students in technical colleges in North-West Nigeria

H_{O2}: There is no significant difference in the mean responses of School-Based SMEs, Industry-Based SMEs and Employers of Labour on the learning activities for inclusion in the PjBL conceptual model for non-technical skills of EIMW students in technical colleges in North-West Nigeria.

Research Methodology

A Mixed Method Research (MMR) design was adopted. MMR is an approach that synergistically integrates both quantitative and qualitative research elements to comprehensively address research questions and provide a more holistic understanding of the subject under investigation (Dawadi *et al*., 2021). The study was conducted in the North West (NW) geopolitical zone of Nigeria. The targeted population for the study was 405 respondents comprising of 147 School-based SMEs (84 EIMW Teachers and 63 Electrical and Electronics Lecturers), 203 Industry-based SMEs (Electrical and Electronics Technologists working in industries) and 55 Employers of Labour. Purposive sampling was used to sample 246 respondents comprising of 91 school-based SMEs (40 EIMW teachers and 51 EET lecturers),123industry-basedSMEs and 32 employers of labour from three (3) states (Kaduna, Kano and Sokoto), out of the seven (7) states that are in NorthWest, Nigeria. The instruments for the study comprised of two distinct instruments. These include structured questionnaire titled: Non-Technical Skills Assessment Questionnaire (NSAQ) to collect quantitative data and Focus Group Discussion (FGD) guide for collecting qualitative data. The instruments; NSAQ and FGD guide, were validated by three experts to establish the reliability of the NSAQ, a pilot test was conducted in Niger State, Nigeria using 10 respondents comprising of five (5) school-based Subject Matter Experts (SMEs), three (3) Industry-based SMEs and Two (2) Employers of Labour in the field of EIMW trade. The pilot test exercise was conducted using split-half method. To calculate the internal consistency of the items within the NSAQ, Cronbach's alpha was used. Cronbach's alpha is a widely accepted measure for assessing the reliability of instruments that consist of multiple items measuring the same construct (Tavakol and Dennick, 2021). The reliability coefficient of the instrument for the seven sections of the instrument (NSAQ) were found to be 0.84, 0.81, 0.83, 0.79, 0.85, 0.82 and 0.80 respectively with an overall reliability coefficient of 0.82 The data collection for this study involved a mixed-method approach, using both questionnaires and FGDs. The PjBL was developed using the following procedures

Identifying Essential Non-Technical Skills for the Model 2 Designing Learning Activities to Integrate Non-Technical Skills 3 Structuring the PjBL Framework 4 Developing Assessment Strategies for Non-Technical Skills 5 Refining the Model Based on Collaborative Input, both qualitative and quantitative data were analyzed based on the research questions and hypotheses formulated for the study. To answer all the research questions, mean and standard deviation were calculated from the survey data. In determining the acceptance level for each item, real limits of number was used. To test all the null hypotheses, Analysis of Variance (ANOVA) was used at a significance level of $p<0.05$. To validate the assumptions of ANOVA used in testing all the hypotheses, Levene's Test for Homogeneity of Variance was conducted. The thematic analysis was utilized to analyze the qualitative data collected.

Results

Research Question: What are the non-technical skills for inclusion in the proposed PjBL conceptual model of EIMW students in technical colleges in North-West Nigeria? The results for answering Research Question One are presented in Table 1a and Table 1b.

Table 1a: Mean and standard deviation of respondents' responses on the non-technical skills for inclusion in the proposed PjBL conceptual model of EIMW students in technical colleges in North-West Nigeria.

S/N	Items	Mean	SD	Decision
1	Collaborative teamwork skills	4.05	.72	Agreed
2	Interpersonal communication skills	4.06	.70	Agreed
3	Problem-solving skills	4.04	.69	Agreed
4	Critical thinking skills	4.15	.67	Agreed
5	Leadership abilities	4.08	.69	Agreed
6	Communication skills (verbal and written)	4.09	.69	Agreed
7	Entrepreneurship and business acumen	4.06	.70	Agreed
8	Digital literacy and technology adaptation	4.06	.69	Agreed
9	Project management skills	4.07	.71	Agreed
10	Ethical judgement and decision-making	4.02	.69	Agreed
11	Time management skills	4.12	.72	Agreed
12	Adaptability and flexibility	4.13	.69	Agreed
13	Artificial intelligence analytical skills	4.08	.68	Agreed
14	Emotional intelligence	4.08	.69	Agreed
15	Customer service skills	4.06	.70	Agreed
16	Negotiation skills	4.11	.67	Agreed
17	Public speaking and presentation skills	4.04	.69	Agreed
18	Creativity and innovation	4.06	.69	Agreed
19	Stress management skills	4.17	.67	Agreed
20	Lifelong learning and self-improvement orientation	4.06	.70	Agreed
	Grand Mean	**4.08**	**.68**	**Agreed**

Table 1a presents the mean and standard deviation values of the respondents on the non-technical skills for inclusion in the proposed PjBL conceptual model of EIMW students in technical colleges in North-West Nigeria, with average mean values ranging from 4.02 to 4.17, standard deviation values ranging from .67 to .72, and a grand mean value of 4.08. The mean values indicated that the respondents generally agreed on the inclusion of all the identified non-technical skills in the proposed model, while the standard deviation values indicated that the responses were closely clustered around the mean, reflecting a high level of agreement among the respondents.

Table 1b: Thematic analysis on the responses regarding the non-technical skills for inclusion in the proposed PjBL conceptual model of EIMW students in technical colleges in North-West Nigeria.

S/N	Main Theme	Sub-themes	Description	Quote
1	Interpersonal and Communication Skills	Collaborative teamwork skills, interpersonal communication skills, communication skills (verbal and written), public speaking and presentation skills, negotiation skills and customer service skills	All twelve participants emphasized the critical role of interpersonal and communication skills in project-based learning and workplace success. They explained that students must work effectively in teams, communicate clearly with peers, supervisors, and clients, and develop confidence in both formal and informal interactions. Public speaking, negotiation, and customer service were identified as important for	*"No matter how skilled they are, if they cannot work with others and communicate clearly, they will struggle in real*

			building student confidence, maintaining positive relationships, and enhancing professional image.	*projects."*
2	Cognitive and Problem-Solving Abilitie	Problem-solving skills, critical thinking skills, creativity and innovation, stress management skills	Ten participants discussed the importance of cognitive and problem-solving abilities as vital for student readiness in technical tasks. They stressed that students must be able to think critically, analyse problems, and devise innovative solutions. The ability to manage stress was also highlighted as necessary for students to cope with workplace pressure and maintain performance.	*"Every day brings new challenges in this work; they must think, solve problems, and manage their stress."*
3	Leadership, Ethics, and Professional Conduct	Leadership abilities, ethical judgement and decision-making, emotional intelligence	Nine participants emphasized the need to instill leadership abilities and ethical judgement in students. They explained that students must be able to take initiative, make responsible decisions, and uphold integrity in their work. Emotional intelligence was mentioned as essential for self-awareness and managing workplace relationships.	*"A good technician is not just about skills but leadership, integrity, and understanding how to work with others."*
4	Workplace and Entrepreneurial Skills	Entrepreneurship and business acumen Project management skills, digital literacy and technology adaptation, artificial intelligence analytical skills	Eight participants discussed the relevance of workplace and entrepreneurial skills, noting that many students will need to be self-reliant or manage small businesses. Participants also stressed that students must be prepared for the evolving digital landscape by acquiring basic AI and technology-related skills.	*"Beyond technical skills, they need to think like business owners and keep up with technology to remain competitive."*
5	Personal Effectiveness and Continuous Learning	Time management skills, adaptability and flexibility and lifelong learning and self-improvement orientation	Seven participants highlighted personal effectiveness and continuous learning as necessary for students to succeed in dynamic work environments. They explained that time management, adaptability, and a commitment to lifelong learning will ensure that students remain relevant and competitive.	*"The industry is changing fast; they must manage their time, adapt quickly, and keep learning to survive."*

Table 1b shows the thematic analysis of the focus group discussion on the non-technical skills for inclusion in the proposed PjBL conceptual model of EIMW students in technical colleges in North-West Nigeria. All twelve participants emphasized interpersonal and communication skills as fundamental for student success. Problem-solving abilities, critical thinking, and stress management were identified by the majority of participants as vital for real-world tasks. Leadership, ethics, and emotional intelligence were also considered essential for workplace readiness. Additionally, entrepreneurial skills, project management, and digital literacy were highlighted as important for self-reliance and adaptability to technological changes.

4.2 Research Question 2: What are the learning activities for inclusion in the PjBL conceptual model for non-technical skills of EIMW students in technical colleges in North-

West Nigeria? The results that address Research Question Two are presented in Table 2a and Table 2b.

Table 2a: Mean and standard deviation of respondents' responses on the learning activities for inclusion in the PjBL conceptual model for non-technical skills of EIMW students in technical colleges in North-West Nigeria.

S/N	Items	Mean	SD	Decision
1	Collaborative group projects should be incorporated to enhance teamwork skills.	4.06	.70	Agreed
2	Role-playing activities should be included to develop students' communication abilities.	4.06	.67	Agreed
3	Problem-solving workshops should be organized to improve critical thinking skills.	4.09	.69	Agreed
4	Peer review sessions should be included to foster constructive feedback and evaluation skills.	4.08	.70	Agreed
5	Time management exercises should be incorporated to enhance organizational abilities.	4.02	.68	Agreed
6	Students should engage in case studies to develop analytical and decision-making skills.	4.16	.69	Agreed
7	Industry-based internships should be made a part of the model to build real-world adaptability.	4.15	.72	Agreed
8	Leadership roles in group tasks should be assigned to develop initiative-taking skills.	4.08	.68	Agreed
9	Debates and discussions should be encouraged to improve verbal communication skills.	4.17	.68	Agreed
10	Simulation of workplace scenarios should be included to promote ethical decision-making.	4.14	.65	Agreed
11	Brainstorming sessions should be used to enhance students' creativity and innovation.	4.08	.71	Agreed
12	Reflection journals should be part of the activities to build self-assessment and introspection skills.	4.07	.69	Agreed
13	Students should engage in community service projects to develop empathy and social responsibility.	4.08	.69	Agreed
14	Mock interviews should be conducted to improve interpersonal and professional communication.	4.07	.72	Agreed
15	Project timelines and milestone tracking should be incorporated to improve planning skills.	4.10	.68	Agreed
16	Problem-based learning tasks should be integrated to teach collaborative problem-solving.	4.12	.66	Agreed
17	Mentorship programs involving industry professionals should be included to build networking skills.	4.04	.70	Agreed
18	Group presentations should be assigned to improve students' public speaking and confidence.	4.13	.72	Agreed
19	Team-building activities should be part of the model to enhance collaborative dynamics.	4.13	.66	Agreed
20	Conflict resolution exercises should be included to develop negotiation and interpersonal skills.	4.10	.65	Agreed
	Grand Mean	**4.09**	**.68**	**Agreed**

Table 2a presents the mean and standard deviation values of the respondents on the learning activities for inclusion in the PjBL conceptual model for non-technical skills of EIMW students in technical colleges in North-West Nigeria, with average mean values ranging from 4.02 to 4.17, standard deviation values ranging from .65 to .72, and a grand mean value of 4.09. The mean values indicated that the respondents generally agreed on the inclusion of all the identified learning activities in the proposed model, while the standard deviation values indicated that the responses were closely clustered around the mean, reflecting a high level of agreement among the respondents.

Table 2b: Thematic analysis on the responses regarding the learning activities for inclusion in the PjBL conceptual model for non-technical skills of EIMW students in technical colleges in North-West Nigeria.

S/N	Main Theme	Sub-themes	Description	Quote
1	Interpersonal and communication development	Collaborative group projects, role-playing activities, debates and discussions, mock interviews, group presentations, conflict resolution exercises	All twelve participants emphasized the need for structured learning activities that promote communication and interpersonal effectiveness. They explained that collaborative group projects, role-playing, debates, and mock interviews would help students build confidence, improve verbal expression, and enhance teamwork. Group presentations and conflict resolution exercises were identified as useful for strengthening public speaking, negotiation, and relationship management skills.	*Most of them struggle to express themselves; activities like role-playing, debates, and group projects will really help their confidence.*
2	Cognitive and problem-solving enhancement	Problem-solving workshops, case studies, brainstorming sessions, problem-based learning tasks	Ten participants discussed the importance of integrating activities that enhance students' critical thinking and problem-solving skills. They highlighted workshops, case studies, and brainstorming sessions as effective for helping students approach challenges creatively and logically. Problem-based learning tasks were also seen as essential for preparing students to collaborate in solving real-world problems.	*Technical work is full of challenges; they need activities that help them think critically and solve problems as a team.*
3	Leadership, ethics, and professional conduct	Leadership roles in group tasks, simulation of workplace scenarios, community service projects	Nine participants stressed the value of activities that promote leadership qualities, ethical decision-making, and social responsibility. They suggested that assigning leadership roles, simulating workplace scenarios, and involving students in community service would help instill initiative, accountability, and empathy.	*It's not enough to teach technical skills; they must learn to lead and take responsibility for their actions in the real world.*
4	Workplace readiness and entrepreneurial orientation	Industry-based internships, mentorship programs involving industry professionals, project timelines and milestone tracking	Eight participants emphasized the importance of practical, workplace-related activities to prepare students for industry demands. They recommended internships, mentorship programs, and project milestone tracking as ways to help students build adaptability, understand professional expectations, and develop basic project management skills.	*There's no better way to prepare them than exposing them to real industry settings and having mentors to guide them.*
5	Personal effectiveness and	Time management	Seven participants highlighted the relevance of activities that promote	*Many of them don't reflect on*

continuous development	exercises, reflection journals	personal organization and self-improvement. They explained that time management exercises would help students plan and meet deadlines, while reflection journals would encourage introspection, self-assessment, and a mindset of continuous learning.	*their work or manage their time properly; these activities will build discipline and self-awareness.*

Table 2b shows the thematic analysis of the focus group discussion on the learning activities for inclusion in the PjBL conceptual model for non-technical skills of EIMW students in technical colleges in North-West Nigeria. All twelve participants emphasized the importance of interactive and communication-based activities to build student confidence and interpersonal effectiveness. The majority of participants also highlighted problem-solving tasks, case studies, and brainstorming sessions as essential for enhancing critical thinking and collaborative problem-solving. Activities promoting leadership, ethical decision-making, and community involvement were seen as vital for holistic student development. Additionally, participants recommended workplace exposure, mentorship, and project management activities to improve industry readiness.

Hypothesis One

There is no significant difference in the mean responses of School-Based SMEs, Industry-Based SMEs, and Employers of Labour on the non-technical skills for inclusion in the proposed PjBL conceptual model of EIMW students in technical colleges in North-West Nigeria. The results for testing Hypothesis One are presented in Table 3.

Table 3: Summary of ANOVA on the mean responses of School-Based SMEs, Industry-Based SMEs, and Employers of Labour on the non-technical skills for inclusion in the proposed PjBL conceptual model of EIMW students in technical colleges in North-West Nigeria.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.652	2	.326	.626	.535
Within Groups	126.551	243	.521		
Total	127.203	245			

Table 3 presents the summary of ANOVA results on the mean responses of School-Based SMEs, Industry-Based SMEs, and Employers of Labour regarding the non-technical skills for inclusion in the proposed PjBL conceptual model of EIMW students in technical colleges in North-West Nigeria. The result shows that the calculated F-value is 0.626 with a corresponding p-value of 0.535, which is greater than the 0.05 level of significance. This implies that there is no significant difference in the mean responses of the three groups on the non-technical skills for inclusion in the proposed PjBL conceptual model, thereby retaining the null hypothesis.

Hypothesis Two

There is no significant difference in the mean responses of School-Based SMEs, Industry-Based SMEs, and Employers of Labour on the learning activities for inclusion in the PjBL conceptual model for non-technical skills of EIMW students in technical colleges in North-West Nigeria. The results obtained from testing Hypothesis Two are shown in Table 4.

Table 4: Summary of ANOVA on the mean responses of School-Based SMEs, Industry-Based SMEs, and Employers of Labour on the learning activities for inclusion in the PjBL conceptual model for non-technical skills of EIMW students in technical colleges in North-West Nigeria.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.361	2	.181	.367	.693
Within Groups	119.724	243	.493		
Total	120.085	245			

Table 4 presents the summary of ANOVA results on the mean responses of School-Based SMEs, Industry-Based SMEs, and Employers of Labour regarding the learning activities for inclusion in the PjBL conceptual model for non-technical skills of EIMW students in technical colleges in North-West Nigeria. The result reveals that the calculated F-value is 0.367 with a p-value of 0.693, which is greater than the 0.05 level of significance. This indicates that there is no significant difference in the mean responses of the three groups on the learning activities for inclusion, thus the null hypothesis is upheld.

Discussion of Findings

The findings on the non-technical skills for inclusion in the proposed Project-Based Learning (PjBL) conceptual model revealed that collaborative teamwork, interpersonal communication, problem-solving, critical thinking, leadership, verbal and written communication, entrepreneurship, digital literacy, project management, ethical judgement, time management, adaptability, AI skills, emotional intelligence, customer service, negotiation, public speaking, creativity, stress management, and lifelong learning were considered essential for Electrical Installation and Maintenance Work (EIMW) students in technical colleges in North-West Nigeria. These skills were identified as necessary to prepare students not only for technical tasks but also for the dynamic and evolving demands of the workplace. The finding implies that stakeholders in technical education have recognised the need to go beyond technical competencies by equipping students with a broad range of non-technical skills that promote holistic development.

The results of this study align with the findings of Muhammad (2014) in Malaysia, who developed a PjBL framework for non-technical skills in electrical engineering students and emphasised similar skill areas such as teamwork, communication, leadership, and critical thinking. Likewise, the study by Dogara et al. (2022) in Nigeria stressed the importance of integrating soft skills, including emotional intelligence, creativity, and problem-solving into technical education through a PjBL framework. Similarly, Miller and Krajcik (2019) noted that project-based learning environments effectively promote critical thinking, communication, and collaborative skills, which are consistent with the current study's results. In contrast, some studies, such as that by Nwokike (2014), focused more narrowly on entrepreneurship and self-employment skills for EIMW students, without highlighting emerging skills like AI skills or digital literacy. The inclusion of AI skills, digital literacy, and lifelong learning in this study's findings reflects a more contemporary understanding of the evolving requirements for the modern workforce, which was not as prominent in earlier studies.

The findings on stakeholders' perceptions revealed that there was no significant difference in the mean responses of School-Based Subject Matter Experts (SMEs), Industry-Based SMEs, and Employers of Labour regarding the non-technical skills for inclusion in the proposed PjBL conceptual model for EIMW students in technical colleges in North-West Nigeria. This suggests a high level of agreement among key stakeholders on the relevance and necessity of the identified non-technical skills. This finding implies that there is a shared understanding across different stakeholder groups concerning the essential non-technical skills required for technical college graduates. The similarity in responses across stakeholders is consistent with the findings of Sada (2016), who developed a problem-based learning conceptual model for technical colleges in North-West Nigeria and reported broad agreement among stakeholders on the importance of integrating problem-solving and teamwork skills. The absence of significant differences in the present study may reflect a stronger alignment between technical colleges and industry in North-West Nigeria compared to other regions or sectors. The reason for this alignment could be attributed to increased industry involvement in technical education initiatives in Nigeria, as highlighted by recent policy directions

encouraging collaboration between colleges and the private sector. The growing recognition that non-technical skills are vital for employability and productivity likely influenced the convergence of opinions among School-Based SMEs, Industry-Based SMEs, and Employers of Labour in this study.

The findings on the learning activities for inclusion in the proposed Project-Based Learning (PjBL) conceptual model revealed that collaborative group projects, role-playing, problem-solving workshops, peer review, time management exercises, case studies, industry-based internships, leadership roles, debates, workplace simulations, brainstorming sessions, reflection journals, community service, mock interviews, project milestone tracking, problem-based learning, mentorship programs, group presentations, team-building activities, and conflict resolution exercises were identified as essential for developing non-technical skills among EIMW students in technical colleges in North-West Nigeria.

The result of this study is in agreement with the work of Milena (2015), who applied PjBL in English classrooms and found that activities like group projects, role-playing, and presentations effectively promoted collaboration, communication, and critical thinking. Similarly, Dogara et al. (2022) emphasised the importance of activities such as team-building exercises, reflection sessions, and mentorship programs as part of a PjBL framework for integrating soft skills into technical college education. Moreover, the study by Sada (2016) also supported the inclusion of problem-solving activities and real-life simulations for enhancing students' critical thinking and decision-making abilities. In contrast, Nwokike (2014) placed more emphasis on entrepreneurship training and skills for self-employment without highlighting a wide variety of learning activities such as workplace simulations or AI-focused exercises, which appear in the current study's findings. Likewise, Banerjee (2015) emphasised conceptual models for IT offshoring success but did not detail specific learning activities to build non-technical competencies through PjBL

The findings further revealed that there was no significant difference in the mean responses of School-Based SMEs, Industry-Based SMEs, and Employers of Labour on the learning activities for inclusion in the proposed PjBL conceptual model for non-technical skills of EIMW students in technical colleges in North-West Nigeria. This indicates a high level of agreement among key stakeholders regarding the most appropriate learning activities to be used for developing non-technical skills. This finding implies that all stakeholder groups recognise the importance of incorporating diverse learning activities, such as collaborative projects, internships, debates, simulations, and mentorship programs, to effectively develop non-technical skills in EIMW students.

This finding is consistent with the study by Muhammad (2014), who reported that stakeholders in Malaysia agreed on the importance of incorporating practical and interactive learning activities into the PjBL framework for engineering students. Likewise, Dogara et al. (2022) found similar consensus among stakeholders regarding the role of structured learning activities in promoting soft skills development in Nigerian technical colleges. In contrast, Banerjee (2015) observed varying stakeholder opinions when developing a conceptual framework for IT offshoring, particularly regarding specific activities for skill development. This variation could be attributed to the differences in industry expectations between IT offshoring and technical vocational education, where more practical, hands-on activities are typically favoured.

The reason for the alignment observed in this study may be due to the increasing collaboration between technical colleges and industries in North-West Nigeria, which has created a shared understanding of the skills and learning experiences required to produce competent graduates. The growing awareness of the limitations of traditional teaching methods and the benefits of experiential learning has likely contributed to this consensus. The

implication of this finding is that the implementation of the proposed PjBL conceptual model is likely to receive broad support, as stakeholders across educational institutions and industry agree on the appropriate learning activities required. This shared perspective provides a strong foundation for the effective introduction of PjBL approaches aimed at developing non-technical skills among EIMW students in technical colleges.

Conclusion

This study was conducted to develop a Project-Based Learning (PjBL) conceptual model for integrating non-technical skills into the training of Electrical Installation and Maintenance Works (EIMW) students in technical colleges in North-West Nigeria. The study became necessary due to the increasing demand for graduates of technical colleges who possess not only technical competencies but also essential non-technical skills required for workplace success in the 21st-century economy. The findings of the study revealed that key non-technical skills such as collaborative teamwork, interpersonal communication, problem-solving, critical thinking, leadership, entrepreneurship, digital literacy, project management, ethical judgement, adaptability, AI skills, emotional intelligence, stress management, and lifelong learning are crucial for inclusion in the proposed PjBL conceptual model. This highlights the broad set of employability and life skills required to complement the technical expertise of EIMW students.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. The National Board for Technical Education (NBTE) should revise the EIMW curriculum to formally integrate the identified non-technical skills such as collaborative teamwork, leadership, digital literacy, AI skills, and emotional intelligence by embedding them into structured PjBL activities to enhance students' employability.

2. EIMW Teachers and Heads of Departments in Technical Colleges should implement the recommended learning activities including collaborative group projects, role-playing, industry-based internships, and workplace simulations during PjBL delivery to promote students' acquisition of non-technical skills.

3. Technical College Administrators should implement the recommended processes such as conducting student orientation sessions, restructuring the curriculum, establishing industry partnerships, and integrating technology to ensure the effective implementation of the PjBL conceptual model.

Reference

Akyazi, T., Goti, A., Oyarbide, A., Alberdi, E., & Bayon, F. (2020). A guide for the food industry to meet the future skills requirements emerging with industry 4.0. *Foods*, *9*(4), 492. https://doi.org/10.3390/foods9040492

Ayodele, T. O., Adegoke, O. J., Kajimo-Shakantu, K., & Olaoye, O. (2021). Factors influencing real estate graduates soft skill gap in Nigeria. *Property Management*, *39*(5), 581–599. https://doi.org/10.1108/PM-08-2020-0051

Banerjee, S. (2015). Development and Validation of a Conceptual Framework for IT Offshoring Engagement Success. In *PhD thesis. University of Bedfordshire. United Kingdom*.

Cobianchi, L., Dal Mas, F., Verde, J. M., Garcia-Vazquez, A., Martellucci, J., Swanstrom, L., & Ansaloni, L. (2022). Why non-technical skills matter in surgery. New paradigms for

surgical leaders. *Discover Health Systems*, *1*(1). https://doi.org/10.1007/s44250-022-00002-w

Compagnucci, L., & Spigarelli, F. (2020). The Third Mission of the university: A systematic literature review on potentials and constraints. *Technological Forecasting and Social Change*, *161*. https://doi.org/10.1016/j.techfore.2020.120284

Dawadi, S., Shrestha, S., & Giri, R. A. (2021). Mixed-Methods Research: A Discussion on its Types, Challenges, and Criticisms. *Journal of Practical Studies in Education*, *2*(2), 25–36. https://doi.org/10.46809/jpse.v2i2.20

Dogara, G., Kamin, Y. Bin, & Saud, M. S. Bin. (2020). The Impact of Assessment Techniques on the Relationship between Work-Based Learning and Teamwork Skills Development. *IEEE Access*, *8*, 59715–59722. https://doi.org/10.1109/ACCESS.2020.2983487

Jackson, D., & Hancock, P. (2020). Non-technical Skills in Undergraduate Degrees in Business: Development and Transfer. *Education Research and Perspectives*, *37*(1), 52–84. http://search.proquest.com/docview/964180555?accountid=13828%5Cnhttp://find.shef.ac.uk/openurl/44SFD/44SFD_services_page?url_ver=Z39.88-2004&rft_val_fmt=info:ofi/fmt:kev:mtx:journal&genre=article&sid=ProQ:ProQ:ericshell&atitle=Non-Technical+Skills+in+Unde

Kim, J., & Park, C. Y. (2020). Education, skill training, and lifelong learning in the era of technological revolution: a review. *Asian-Pacific Economic Literature*, *34*(2), 3–19. https://doi.org/10.1111/apel.12299

Kövesi, K., & Kálmán, A. (2020). How to manage the study-to-work transition? a comparative study of Hungarian and French graduate engineering students' perception of their employability. *European Journal of Engineering Education*, *45*(4), 516–533. https://doi.org/10.1080/03043797.2019.1622654

Noah, J. B., & Abdul Aziz, A. (2020). A Systematic review on soft skills development among university graduates. *EDUCATUM Journal of Social Sciences*, *6*(1), 53–68. https://doi.org/10.37134/ejoss.vol6.1.6.2020

Milena, K. (2015). Application of project based learning in English Classroom. In *Unpublished Master's thesis,* University of West Bohemia, Faculty of Education, Plzeň, Czech Republic.

Miller, E. C., & Krajcik, J. S. (2019). Promoting deep learning through project-based learning: a design problem. *Disciplinary and Interdisciplinary Science Education Research*, *1*(1). https://doi.org/10.1186/s43031-019-0009-6

Muhammad, K. B. N. (2014). Project-Based Learning Framework for Non-Technical Skills. *Doctoral dissertation*, Universiti Teknologi Malaysia

Muhd Khaizer, M., Zakaria, N., & Yusof, N. (2020). Evaluating the impact of soft skills assessment on employability in vocational education. Journal of Career Development, 47(1), 45–58.

Munir, F. (2022). More than technical experts: Engineering professionals' perspectives on the role of soft skills in their practice. *Industry and Higher Education*, *36*(3), 294–305. https://doi.org/10.1177/09504222211034725

Nwokike, C. J. (2014). Sklls Required by Graduates of Technical Colleges for Self Employment in Electrical Installation and Maintenance Works in Enugu State. *Unpublished master's thesis*, University of Nigeria, Nsukka

O'Brien, A., Arnold, S., & Kerrigan, P. (2021). *University Graduates from the Perspective of Creative Industries Employers*. 55–75. https://doi.org/10.1007/978-3-030-66033-8_4

Rani, M. E. S. (2021). Need and Importance of Soft Skills in Students. *Journal of Literature, Culture and Media Studies*, *2*(3), 1–6.

Sada, A. M. (2016). Problem-Based Learning Conceptual Teaching Model for Technical Colleges in the North-Western Nigeria. In *Thesis Work*.

Sony, M., & Naik, S. (2020). Industry 4.0 integration with socio-technical systems theory: A systematic review and proposed theoretical model. *Technology in Society*, *61*, 101248. https://doi.org/10.1016/j.techsoc.2020.101248

Srivatanakul, T., & Annansingh, F. (2022). Incorporating active learning activities to the design and development of an undergraduate software and web security course. *Journal of Computers in Education*, *9*(1), 25–50. https://doi.org/10.1007/s40692-021-00194-9

Tavakol, M., & Dennick, R. (2021). Making sense of Cronbach's alpha. *International Journal of Medical Education, 2*, 53-55.

ARTIFICIAL INTELLIGENCE (AI) AS A MEANS OF PROMOTING TECHNICAL AND VOCATIONAL EDUCATION TVET FOR ECONOMIC DIVERSIFICATION IN NIGERIA

ATIKA FARUK GARBA
DEPARTMENT OF GENERAL STUDIES EDUCATION (GSE)
FACULTY OF EDUCATION
YUSUF MAITAMA SULE FEDERAL UNIVERSITY OF EDUCATION, KANO
P.M.B 3045 KANO STATE
GSM No.: 0801548121
EMAIL ADDRESS: afarukgarba@gmail.com

Abstract
The integration of Artificial Intelligence (AI) into Technical and Vocational Education and Training (TVET) presents a transformative opportunity for economic diversification in Nigeria. As a nation highly dependent on oil revenue, Nigeria faces the urgent need to develop a more resilient and diversified economy. AI-driven TVET programs can enhance skill acquisition, improve workforce productivity, and foster innovation in key non-oil sectors such as agriculture, manufacturing, information technology, and renewable energy. This paper explores the role of AI in revolutionizing TVET through intelligent tutoring systems, adaptive learning platforms, and automation in skill-based training. AI-powered tools can personalize education, provide real-time feedback, and simulate hands-on experiences, making technical education more effective and accessible. Moreover, AI-driven analytics can help identify skill gaps and align TVET curricula with the evolving demands of the labor market, ensuring that graduates possess relevant competencies for emerging industries. Despite its potential, integrating AI into Nigeria's TVET system faces several challenges, including inadequate digital infrastructure, limited access to AI resources, and the need for capacity building among educators. Additionally, concerns about job displacement due to automation must be addressed through policies that promote AI-human collaboration rather than replacement..

Key words: Artificial Intelligence, Modern, Instructional Technique, Entrepreneurship Education

Introduction
Teachers in technical and vocational fields, who are tasked with preparing students for labour market that is rapidly evolving have long faced the challenges of adjusting their lessons to keep up with the ever-changing nature of the technologies they use in the classroom. Technical and vocational teaching are reminded by the problems that they need to reply on their prior experience in the field. As a single instructional technology instrument, the computer and its related technology have become an important tool for teaching and learning across all high education systems in fields as diverse as science, technology and language. According to Dauda (2015) and Isiyaku Ayub, and Abdulkadir (2018) technical and vocational teachers in Nigerian universities often need more specialized knowledge to integrate computers and related innovations into their curricular effectively. To ensure that TVET graduates are of high quality and prepared to address the issues of the production sections, it is important to emphasize the competence of TVET teachers.

Technical and Vocational Education and Training (TVET) is crucial for developing skilled labor, driving economic growth, and reducing unemployment in Nigeria. With the rapid advancement of technology, Artificial Intelligence (AI) is emerging as a transformative tool in enhancing the effectiveness and accessibility of TVET (Russell & Norvig, 2016). AI's ability to personalize learning, automate tasks, and provide real-time feedback has the potential to revolutionize the delivery of vocational and technical education in the country.

AI in Education

AI's application in education has been widely studied, with research indicating that AI can significantly enhance learning outcomes through personalized learning, intelligent tutoring systems, and automated grading. AI-powered tools can analyze students' learning patterns and provide tailored content that meets their individual needs, making education more effective and engaging. The rapid evolution of technology in the 21st century has ushered in a new era of possibilities in various sectors, with education being one of the most impacted. Artificial Intelligence (AI), a subset of computer science that focuses on creating systems capable of performing tasks that usually require human intelligence, has become a transformative force in the global educational landscape. In Nigeria, a country with a burgeoning youth population and a pressing need for educational reform, AI presents a unique opportunity to bridge gaps in access, quality, and efficiency in education.

AI and Skills Development

In the context of TVET, AI has the potential to bridge the skills gap by providing learners with hands-on experience through simulations, virtual labs, and interactive content. These AI-driven tools can replicate real-world scenarios, allowing students to practice and refine their skills in a controlled environment before transitioning to the workplace.

The Concept of TVET

TVET in the National Policy on Education Federal Republic of Nigeria (2004) as a comprehensive term alluding as the part of the instructive educational procedure including notwithstanding broad training to general education, the study of advancement and most sciences procurement of practical skills, attitudes, mentalities, comprehension and information on identifying with occupation in areas of telecommunications, broadcasting and related media. Afeti (2007) TVET is a diverse range of training that prepares people for useful work as semi-skilled labourers or gifted specialists. The term vocational technical education (TVET) refers to the type of schooling that equips students with the theoretical and practical know-how necessary to enter the workforce, either as employees or as self-employed professionals. The value of Education (TVET) emphasizes developing skills and knowledge necessary for successful employment and independent living. TVET programs in middle schools in developed nations prepared students for career in manufacturing and other service industries. All TVE programs should have their primary goal the acquisition of knowledge and abilities useful in a specific occupation. TVE programs are found to produce the skilled workers in a country needs to develop its economy and escape its dreamy state of poverty. TVE is notable for having varying levels of complexity in its delivery.

International Centre for Technical and vocational education and training (TVET) (2017) recommends various methods for delivery the knowledge and skills necessary to succeed in a given profession regardless of location subject matter or training provider, training preparing and developing skills in various technical, vocational and industry-related fields, products services and occupation are all part of TVET. Vocational Education and Training (VET) is an educational training that provides the necessary skills, knowledge and competences for a specific occupation or trade. The purpose of VET is to prepare students for a particular job or work-related functions in various sectors of life (Luckin, 2017).

Technical education refers to the programs and courses that focus on developing skills, knowledge and competences in specific technical fields. Technical education aims to prepare students for:

1. Empowerment in specific industries
2. Career advancement
3. Entrepreneurship
4. Further education and training
5. Certifications and licenses

Technical education and training are essential for:

1. **Developing skilled workforce**: Technical education provides students with practical skills and knowledge, making them job-ready.
2. **Addressing industry needs**: Technical education fills labour market gaps by providing training professionals in specific industries.
3. **Promoting economic growth**: Technical education contributes to economic development by creating a competent and productive workforce.
4. **Enhancing employability:** technical education graduates have better job prospects and higher earning potential.
5. **Encouraging innovation:** Technical education fosters innovation and entrepreneurship, driving technological advancement.
6. **Improving productivity:** technical education enhances productivity as trained professionals are more efficient and effective.
7. **Supporting industrial development:** technical education helps industries stay competitive by providing specialized workers.
8. **Fostering lifelong learning:** technical education instills a culture of continuously earning, essential for adapting to technological changes.
9. **Bridging the skills gap;** technical education addresses the skills gap between education and industry requirements.
10. **Preparing for future jobs:** technical education prepares students for emerging industries and jobs of the future.

The Role of AI in Nigerian Education

AI in education offers multiple advantages, ranging from personalized learning experiences to efficient administrative processes. In Nigeria, where educational challenges include overcrowded classrooms, insufficient teaching staff, and limited access to quality learning materials, AI can serve as a powerful tool to mitigate these issues (Kawu, & Oyelade, 2021).

1. **Personalized Learning**

One of the most significant impacts of AI in education is its ability to provide personalized learning experiences. AI-powered platforms can analyze students' learning patterns, strengths, and weaknesses, offering tailored educational content that meets their individual needs. For example, adaptive learning systems like Smart Sparrow and Carnegie Learning use AI algorithms to adjust the difficulty level of tasks based on the learner's progress (Okonkwo & Ade-Ibijola, 2020). In Nigeria, where many students struggle with standardized teaching methods, such adaptive learning systems can help accommodate different learning paces and styles, thereby enhancing student engagement and comprehension.

2. **AI-Powered Tutoring Systems**

AI-driven tutoring systems, such as chat bots and virtual tutors, can provide students with immediate feedback and support, even outside the classroom. These tools can be particularly beneficial in Nigeria, where teacher-to-student ratios are often high, and many

students do not receive the individualized attention they need. Virtual tutors like IBM's Watson Tutor can assist students with homework, explain complex concepts, and even simulate one-on-one tutoring sessions, helping to alleviate the burden on teachers and improve student outcomes.

3. **Educational Content Creation and Curation**

AI can also streamline the process of creating and curating educational content. For instance, AI tools like Content Technologies, Inc. (CTI) can automatically generate textbooks and learning materials tailored to specific curricula. This capability is especially relevant in Nigeria, where there is often a shortage of up-to-date and culturally relevant educational resources. By using AI to generate content that aligns with the Nigerian curriculum, educators can ensure that students have access to relevant, high-quality learning materials.

4. **Assessment and Evaluation**

AI has the potential to revolutionize the way assessments are conducted in Nigerian schools. Traditional assessment methods, such as standardized tests, may not accurately reflect a student's understanding or skills. AI can provide more nuanced and continuous assessments by analyzing a student's performance across various tasks and assignments. Automated grading systems, like those used in EdTech platforms such as Coursera, can also provide instant feedback, helping students learn from their mistakes and teachers save time on grading.

5. **Improving Access to Education**

In a country like Nigeria, where there are significant disparities in access to education between urban and rural areas, AI can play a crucial role in democratizing education. AI-powered educational platforms can be accessed remotely, allowing students in underserved regions to benefit from quality education without the need for physical infrastructure. For example, online learning platforms like Alison and Udemy offer courses that can be accessed by anyone with an internet connection, providing opportunities for lifelong learning and skills development.

6. **Language Translation and Support**

Nigeria is a multilingual country with over 500 languages spoken across its regions. Language barriers can be a significant obstacle to education, particularly in rural areas. AI-powered translation tools, such as Google Translate, have the potential to break down these barriers by providing real-time translation and language support. This can enable students to access educational content in their native languages, making learning more inclusive and effective.

How Artificial Intelligence (AI) can influence vocational Education and training in Nigeria

According to Holmes, Bialik, and Fadel, (2019), including:

1. **Personalized Learning**: AI powered adaptive learning system can tailor training to individual students needs and abilities.
2. **Virtual simulations**: AI driven simulations can mimic real world environments, allowing students to practice skills in a safe and controlled space.
3. **Intelligent tutoring systems:** AI based virtual mentors can provide one on one guidance and fed back to students.
4. **Predictive analytics:** AI algorithms can identify at risk students and provide early interventions to improve retention and completion rates.
5. Automated assessment AI-Powered tools can streamline assessment processes, reducing the burden on instructors and providing instant feedback to students.
6. **Enhanced Accessibility:** AI-powered virtual learning platforms can increase access to education for marginalized or remote communities.

7. **Industry-**relevant skills: AI can help align vocational education with industry needs, preparing students for in-demanded jobs.
8. **Data Analysis:** AI can help analyse students' data to improve training programs and instructor effectiveness.
9. **Virtual Mentorship:** AI powered virtual mentors can provide guidance and support to students, especially in areas with limited instructor availability.
10. **Access to global resources:** AI-powered platforms can connect Nigerian students with global resources, expects, and best practices.

According to Baker and Smith (2019). To promote vocational education and training in Nigeria the following solutions can be implemented

1. **Increased funding:** Allocate more resources to vocational education and training program.
2. **Industry partnerships:** Collaborate with industries to provide practical training and job opportunities.
3. **Curriculum reform:** Align vocational education curriculum with industry needs and global standards.
4. **Infrastructure development:** Improve facilities and equipment for vocational training.
5. **Teacher training:** Provide on-going training for vocational education instructors.
6. **Awareness campaigns:** promote vocational education and training through awareness campaigns.
7. **Apprenticeships:** Encourage apprenticeships and on the job training.
8. **Certification and accreditation:** Establish recognised certification and accreditation processes.
9. **Entrepreneurship training:** Integrate entrepreneurship training into vocational education programs.
10. **Government support:** Encourage government policies and initiatives supporting vocational education and training.
11. **Private sector involvement:** Encourage private sector investment in vocational education and training.
12. **Community engagement:** Engage local communities in promoting vocational education and training.

The Objectives of Vocational Technical Education in Nigeria

In a report issued by the Comparative Technical Education Seminar Abroad (1996) the following objectives were recommended for a national plan of vocational – technical education in the republic of Nigeria.

1. To provide technological literacy to all pupils that is to prepare every pupil for life in technological age.
2. To help develop the right attitude towards work and the habits of mind conducive to the proper use of technology.
3. To provide adequate technological orientation and preparation for advanced professional education and training in technology.
4. To equip school leavers with skills to earn living.
5. To stimulate and encourage creativity.
6. To provide the awareness that technology does not only solve problems but creates some as well.

Challenges of Implementing AI in Nigerian Education

Despite the potential benefits of AI in education, several challenges need to be addressed to realize its full potential in Nigeria.

1. **Infrastructure and Connectivity**

The implementation of AI in education requires robust technological infrastructure, including reliable internet access, electricity, and digital devices. In Nigeria, many schools, particularly in rural areas, lack these basic necessities. Without addressing these infrastructural challenges, the benefits of AI may remain out of reach for a significant portion of the population.

2. **Digital Literacy**

For AI to be effectively integrated into education, both educators and students need to be digitally literate. In Nigeria, however, there is a significant digital literacy gap, particularly among teachers who may not be familiar with the latest technological tools. Training and capacity-building programs are essential to equip educators with the skills needed to leverage AI in their teaching practices.

3. **Cost of Implementation**

The cost of implementing AI solutions in education can be prohibitive, especially in a developing country like Nigeria. Investing in AI-powered platforms, training, and infrastructure requires significant financial resources, which may be challenging for public schools with limited budgets. Public-private partnerships and government support will be crucial in overcoming this barrier.

4. **Ethical and Privacy Concerns**

The use of AI in education also raises ethical and privacy concerns, particularly regarding the collection and use of student data. Ensuring that AI systems are transparent, secure, and comply with data protection regulations is essential to maintain trust and protect students' privacy.

The Influence of (AI) Artificial Intelligence in Transforming Technical and vocational Education and Training in Nigeria (TVET) Fostering Economic Diversification

1. Enhancing Curriculum and Skill Relevance

AI enables the dynamic updating of TVET curricula to align with current and emerging market demands. Intelligent systems can analyze labour market trends and suggest new modules or courses, ensuring that students acquire in-demand skills such as robotics, automation, digital fabrication, and smart agriculture. This responsiveness makes TVET programs more relevant and effective in preparing learners for the workforce.

2. Personalized and Adaptive Learning

AI-powered learning platforms can deliver personalized content based on individual student performance and learning pace. This is particularly useful in TVET, where learners have diverse educational backgrounds. Through adaptive learning systems, students can receive customized support, enhancing their understanding and retention of technical skills.

3. Simulation and Virtual Reality Training

AI-driven simulations and virtual reality (VR) environments provide practical training experiences without the high cost of physical infrastructure. For instance, learners can practice welding, engine repair, or electrical installations in virtual environments, gaining hands-on skills in a safe, cost-effective way. This reduces equipment wear and safety risks while improving learning outcomes.

4. Intelligent Assessment and Feedback

AI tools can automate the assessment of student performance through smart quizzes, coding platforms, and skill-based simulations. These tools provide immediate feedback, helping learners improve more quickly. Instructors can also use AI analytics to identify struggling students and intervene early, improving overall program success rates.

5. Expanding Access and Inclusion

AI-powered mobile apps and online platforms make TVET more accessible to students in rural and underserved areas. Voice-assisted tools in local languages, automated translation, and chat bots for career guidance can remove language and location barriers, fostering inclusive learning and supporting gender equity in skill development.

6. Supporting Economic Diversification

By equipping Nigerians with AI-relevant technical and vocational skills, TVET becomes a driver of economic diversification. Skilled graduates can contribute to sectors such as agriculture, renewable energy, manufacturing, and digital services. Start-ups and small businesses fueled by tech-savvy youth can thrive, reducing unemployment and dependence on oil revenue.

7. Challenges and the Way Forward

Despite its potential, integrating AI into TVET faces challenges such as inadequate infrastructure, limited digital literacy among teachers, and funding constraints. To overcome these, the Nigerian government must invest in ICT infrastructure, train instructors in AI tools, and partner with the private sector to fund innovation in TVET.

Conclusion

By embracing AI in vocational education and training, Nigeria can enhance the quality and relevance of training programs, improve student outcomes, and better prepare worker for the modern workforce. AI has the potential to transform education in Nigeria by addressing some of the most pressing challenges facing the sector. From personalized learning and AI-powered tutoring to improving access and content creation, AI can enhance the quality and accessibility of education across the country. However, realizing this potential requires addressing infrastructural, financial, and ethical challenges through strategic investments, policy support, and capacity-building initiatives. By embracing AI, Nigeria can create a more inclusive, effective, and future-ready educational system that equips its students with the skills needed to thrive in the 21st century. AI in TVET has in potential to equip Nigerians with future ready skills, dividing economics growth and diversification if strategically. If strategically implemented it could prams for Nigeria into a hub for skilled labour across various industries.

Recommendations

To achieve AI in promoting vocational and technical education, the following recommendations are made:

1. Vocational education is needed for students attending post-secondary schools. These students need vocational education in order to enable them become skilled in traders and various technical occupations.
2. Vocational education is needed by young people who have left a full time school career, those employed and those who have been rendered unemployed due to technological changes.
3. Vocational education is needed by who because of academic socio-economic or other handicaps, cannot succeed in regular vocational programmes.
4. Vocational and technical education should provide an orientation and preparation for those who have the skills.
5. Vocational and technical education should provide an orientation and basic skills with which to start a life of work for the vast majority of pupils.

In addition, the government should give adequate attention to promote artificial intelligence AI in technical and vocational education and training in Nigeria through

providing adequate facilities and techniques, qualified teachers whom to train the individuals conducive environment for the training of the skills, good consideration and support to encourage individual participation into the programme. It is equally important for the government to make sure that technical and vocational education at all level of education are made relevant to provide the youths and graduate with the needed skills.

References

Afeti, G. (2007). Strategy to revitalize Technical and Vocational Education and Training (TVET) in Africa. In Meeting of the Bureau of the Conference of Ministers of Education of the African Union, Cape Town, South Africa.

Baker, T., & Smith, L. (2019). *Educ-AI-tion Rebooted? Exploring the future of Artificial Intelligence in schools and colleges*. Nesta.

Bhard A& Tiwens (2021) The Role of Artificial of Letter Intelligence in Vocations Education Publishing in the Journal of Education and Practice.

Dauda, I. D. (2015). Predictive modelling of the effects of perceived usefulness and perceived ease of use on teachers use of ICTs in tertiary colleges of North-western Nigeria. *Journal of Contemporary Education Research*, 5(1), 136-151

FRN (2004). *National Policy on Education.* Lagos. NERDC Press.

Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial Intelligence in Education: Promises and Implications for Teaching and Learning*. Center for Curriculum Redesign.

Indel Economic Forum (2020) The Future of Jobs Paper

International Center for Technical and Vocational Education and Training. (2017). Our places within the un system. Retrieved from https://bit.ly/3oZhYT7

International Labor Organisation (2020) Skills for a Creator Future.

Isiyaku, D. D., Ayub, M. A. F., & AbdulKadir, S. (2018). Antecedents to teacher's perceptions of the usefulness of ICTs for business education classroom instructions in Nigerian tertiary institutions. Asia Pacific Education Review, 19(3), 337-352. doi:https://doi.org/10.1007/s12564-018-9525-x.

Kawu, M. I., & Oyelade, E. A. (2021). The impact of artificial intelligence on education in Nigeria: Prospects and challenges. *Journal of Information and Technology Education*, 9(1), 45-59.

Luckin, R. (2017). *Towards Artificial Intelligence-Based Assessment Systems*. Learning Sciences and Assessment Institute.

National Board for Technical Education Nigeria (MBTE) Reform in Technical and Vocational Education and Training in Nigeria.

Nwalog U.J. & Nmenekezir, Au (2017) The Peele of Technical and Vocation Eduction Economcis Diversifical in Nigeria

Okonkwo, C. W., & Ade-Ibijola, A. (2020). *AI in Nigerian education: Unlocking the potential for national development*. Journal of Educational Technology Development and Exchange, 13(2), 63-79.

Russell, S., & Norvig, P. (2016). *Artificial Intelligence: A Modern Approach* (3rd ed.). Pearson.

UNESCO (2021) Artificial Intelligence in Education: Challenge and Opportunities for Sustainable Hhedlpment