



**EMPIRICAL RESEARCH INSTITUTE OF NIGERIA**

**2<sup>ND</sup> INTERNATIONAL HYBRID CONFERENCE/ INDUCTION 2026**

**THEME:**

**AFRICANIZING RESEARCH METHODS  
FOR SUSTAINABLE ECONOMIC GROWTH  
AND ENTREPRENEURSHIP EMPOWERMENT**

  
**CONFERENCES HALL,  
FACULTY OF SOCIAL SCIENCES,  
REV. FR. MOSES ORSHIO ADASU  
UNIVERSITY, MARKURU**

  
**10TH - 13TH  
MARCH, 2026**



**EMPIRICAL RESEARCH INSTITUTE OF NIGERIA**  
**2<sup>ND</sup> INTERNATIONAL HYBRID**  
**CONFERENCE/INDUCTION CEREMONY**

# **BOOK OF PROCEEDING**

**THEME: AFRICANIZING RESEARCH METHODS FOR SUSTAINABLE ECONOMIC GROWTH AND ENTREPRENEURSHIP EMPOWERMENT**

| 📅 DATE: 10<sup>TH</sup> - 13<sup>TH</sup> MARCH, 2026 |

| 📍 LOCATION: CONFERENCES HALL, FACULTY OF SOCIAL SCIENCES. REV. FR. MOSES ORSHIO  
ADASU UNIVERSITY, MARKUDI, BENUE STATE, NIGERIA |

| ⌚ TIME: 10:00 AM DAILY (WAT) |

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Department of Accounting, Alex Ekwueme Federal  
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- Ifeanyichukwu Tina Ossai**  
Federal College of Agriculture Ishiagu, Ebonyi State Nigeria

## CONFERENCE INTRODUCTION

Distinguished Governing Council Chairman, keynote speakers, invited guests, respected scholars, inductees, colleagues, ladies and gentlemen,

The Second International Hybrid Conference and Induction Ceremony of the Empirical Research Institute of Nigeria (ERIN) marks an important milestone in the Institute's continuing commitment to advancing scholarly excellence, intellectual collaboration, and impactful research within Africa and the global academic community. This distinguished gathering brings together eminent scholars, seasoned researchers, policy experts, entrepreneurs, and development practitioners to deliberate on issues central to Africa's developmental transformation. It provides a vibrant platform for the exchange of ideas, critical reflection, and the generation of innovative research perspectives capable of addressing contemporary socio-economic challenges.

The theme of this conference, **"Africanizing Research Methods for Sustainable Economic Growth and Entrepreneurship Empowerment,"** reflects a timely and purposeful intellectual call. For decades, the practice of research in African has often relied predominantly on frameworks and methodologies developed outside the continent. While such contributions have enriched global scholarship, there is an increasing recognition of the necessity to integrate indigenous knowledge systems, cultural realities, and contextual experiences into research design and implementation. Africanizing research methods therefore represents not merely an academic preference, but a strategic imperative for producing knowledge that is relevant, practical, and transformative for African societies.

This conference seeks to stimulate rigorous scholarly discourse on how contextualised research methodologies can foster sustainable economic growth and strengthen entrepreneurial capacity across the continent. By encouraging interdisciplinary engagement and empirical inquiry rooted in African realities, the gathering aims to inspire new models of knowledge production capable of informing public policy, enhancing innovation, and empowering emerging entrepreneurs.

The hybrid format of the conference further reflects the evolving landscape of global academic engagement. By combining physical and virtual participation, the event expands opportunities for wider intellectual participation, thereby strengthening international collaboration and enabling scholars from diverse geographical locations to contribute meaningfully to the conversation.

Equally significant is the induction ceremony, which symbolises the Institute's commitment to nurturing a new generation of researchers devoted to ethical scholarship, empirical rigour, and societal relevance. As ERIN continues to build a dynamic community of scholars, this conference stands as a clarion call for collective intellectual responsibility encouraging participants to harness research as a powerful instrument for sustainable development, entrepreneurial empowerment, and the enduring advancement of Africa's knowledge economy.

## CONFERENCE OBJECTIVES

The 2nd International Hybrid Conference and Induction Ceremony is designed to achieve several strategic academic and developmental objectives that will advance research excellence and strengthen Africa's contribution to global knowledge production.

- 1. To promote African-centred research methodologies:** One of the central objectives of the conference is to encourage the development and application of research methods that reflect Africa's socio-cultural realities, indigenous knowledge systems, and local developmental needs. This will enhance the relevance and applicability of research findings to African contexts.
- 2. To foster interdisciplinary scholarly collaboration:** The conference seeks to bring together scholars and professionals from diverse academic disciplines to share ideas, experiences, and research findings. This collaboration will stimulate innovative thinking and strengthen the integration of knowledge across fields for comprehensive solutions to development challenges.
- 3. To stimulate research-driven economic growth:** Another objective is to examine how empirical research can contribute to sustainable economic development in Africa by informing policies, guiding strategic investments, and supporting evidence-based decision-making processes.
- 4. To empower entrepreneurship through knowledge and innovation:** The conference aims to highlight the role of research in fostering entrepreneurial development, innovation, and enterprise sustainability. By connecting academic research with practical economic opportunities, participants will explore strategies for strengthening entrepreneurial ecosystems across Africa.
- 5. To strengthen global academic networking and partnerships:** Through its hybrid format, the conference intends to expand international collaboration among scholars, institutions, and research organisations, thereby encouraging knowledge exchange and long-term research partnerships.
- 6. To promote ethical standards and excellence in research practice:** The gathering also seeks to reinforce the importance of integrity, methodological rigour, and professional responsibility in empirical research.
- 7. To induct and inspire emerging scholars and researchers:** Finally, the induction ceremony aims to welcome new members into the scholarly community of ERIN, inspiring them to uphold the highest standards of academic excellence and contribute meaningfully to Africa's intellectual and socio-economic advancement.

## **CONFERENCE THEMES**

To enrich scholarly engagement and encourage diverse intellectual contributions, the Conference has identified the following sub-themes:

### **1. Indigenous Knowledge and African-Centred Research Methods**

This sub-theme explores the integration of indigenous knowledge systems and African cultural realities into research design, methodology, and knowledge production. It encourages scholars to develop contextually relevant frameworks that strengthen the authenticity and applicability of research conducted within African societies.

### **2. Education Research for Sustainable Development in Africa**

Focus is placed on how educational research can contribute to sustainable development across the continent. Discussions may examine curriculum innovation, educational policy reforms, capacity building, and strategies for strengthening research culture within African institutions.

### **3. Science-Driven Research and Innovation for Economic Growth**

This theme highlights the role of scientific research and technological innovation in driving economic development, industrial productivity, and sustainable competitiveness within emerging African economies.

### **4. Technology, Digitalisation, and AI-Enabled Research Methods**

Participants are encouraged to explore the transformative role of digital technologies, artificial intelligence, big data analytics, and emerging technological tools in enhancing modern research methodologies and data-driven decision-making.

### **5. Entrepreneurship, SMEs, and Informal Sector Development**

This sub-theme examines the importance of entrepreneurship and small and medium-sized enterprises (SMEs) as catalysts for employment generation, poverty reduction, and economic resilience within African economies.

### **6. Management, Leadership, and Organisational Research in Africa**

Scholars will examine leadership dynamics, organisational behaviour, institutional effectiveness, and management strategies that promote innovation, accountability, and sustainable organisational growth.

### **7. Participatory and Community-Based Research Approaches**

This area focuses on inclusive research practices that actively involve communities, local stakeholders, and grassroots organisations in the research process to ensure relevance, ownership, and sustainable impact.

## **8. Research-Informed Policy, Governance, and Public Management**

The theme addresses the role of empirical research in shaping effective public policies, strengthening governance frameworks, and improving transparency, accountability, and institutional performance.

## **9. Gender, Youth, and Inclusive Entrepreneurship Research**

Attention is given to research that promotes gender equity, youth empowerment, and inclusive economic participation through entrepreneurship and innovation.

## **10. Sustainable Finance, Green Economy, and Climate-Smart Innovation**

This sub-theme explores financial models, green technologies, and climate-responsive innovations that support environmentally sustainable economic growth across Africa

ERIN 2ND E-PROCEEDING

## **ADDRESSES/SPEECHES**

### **WELCOME ADDRESS BY THE CHAIRMAN, LOCAL ORGANIZING COMMITTEE**

Distinguished Governing Council Chairman, keynote speakers, invited guests, respected scholars, inductees, colleagues, ladies and gentlemen,

On behalf of the Local Organizing Committee, it is my great honor and privilege to warmly welcome you to the 2nd International Hybrid Conference and Induction Ceremony of the Empirical Research Institute of Nigeria (ERIN).

We are delighted to host you here at Benue State University, Makurdi, and to also welcome participants joining us virtually from different parts of Nigeria and across the globe. Your presence, whether physical or virtual, adds value, diversity, and strength to this gathering.

This year's theme, "Africanizing Research Methods for Sustainable Economic Growth and Entrepreneurship Empowerment," speaks directly to the urgent need for research approaches that reflect our realities, address our challenges, and unlock our continent's immense potential. As organizers, we are proud to provide this platform for intellectual exchange, innovation, and professional collaboration.

Planning this conference has required dedication, coordination, and teamwork. I sincerely appreciate the Governing Council, members of the organizing committee, partners, and volunteers whose tireless efforts have made this event possible. Despite challenges, their commitment and resilience have brought us to this moment.

To our presenters, we look forward to insightful discussions and impactful contributions. To our inductees, we congratulate you in advance and welcome you into a professional community committed to excellence and service.

As we begin this conference, I encourage everyone to actively participate, network meaningfully, and share knowledge generously. May this event foster new collaborations, strengthen professional bonds, and inspire practical solutions for sustainable development.

Once again, I warmly welcome you all and wish you a productive and rewarding conference.

Thank you.

## **SPEECH BY THE GOVERNING COUNCIL CHAIRMAN/PRESIDENT**

Distinguished scholars, esteemed colleagues, honored guests, inductees, partners, ladies and gentlemen,

It is with great pleasure and a deep sense of responsibility that I welcome you all to the 2nd International Hybrid Conference and Induction Ceremony of the Empirical Research Institute of Nigeria (ERIN).

This gathering reflects our shared commitment to advancing knowledge, strengthening research capacity, and fostering sustainable development across Africa and beyond. I am particularly delighted to see participants joining us both physically and virtually, which demonstrates the expanding reach and relevance of our Institute.

The theme of this year's conference, "Africanizing Research Methods for Sustainable Economic Growth and Entrepreneurship Empowerment," is both timely and strategic. For too long, research methodologies applied within our environment have not always reflected our local realities, indigenous knowledge systems, and socio-economic contexts. Today, we take bold steps toward redefining research approaches that are rooted in African experiences while remaining globally competitive.

Research must not exist in isolation. It must respond to societal needs, drive innovation, influence policy, and empower entrepreneurs. Sustainable economic growth in Africa requires research that is practical, contextual, and solution-oriented. This conference therefore provides a platform for dialogue, collaboration, and the exchange of transformative ideas.

As Governing Council Chairman/President, I reaffirm the Institute's commitment to integrity, academic excellence, inclusiveness, and professional development. We remain dedicated to building a research community that supports emerging scholars, recognizes established professionals, and promotes interdisciplinary collaboration.

To our presenters, I encourage you to share boldly and engage constructively. To our inductees, today marks the beginning of a greater responsibility. Membership in ERIN is not merely ceremonial; it is a call to service, innovation, mentorship, and ethical leadership in research and professional practice.

I wish to appreciate the Local Organizing Committee, our partners, sponsors, and all members whose dedication and sacrifices have made this event possible. Your collective efforts demonstrate what can be achieved when vision meets commitment.

As we deliberate over the coming days, may our discussions produce actionable insights, strategic partnerships, and long-term impact.

On behalf of the Governing Council, I hereby declare the 2nd International Hybrid Conference and Induction Ceremony officially open.

Thank you, and may our engagements be fruitful and impactful.

# LIST OF CONTRIBUTORS

**Titilayo Olufunmibi ADEWALE-OJO<sup>1</sup>, BADERIN, Adeyemi Gideon<sup>2</sup> & OBANLA, Adebayo Bankole<sup>3</sup>**

<sup>1,2</sup> Department of Mass Communication, Ogun State Institute of Technology, Igbesa, Ogun State, Nigeria.

<sup>3</sup> Public Administration Department, Ogun State Institute of Technology, Igbesa, Ogun State, Nigeria.

Email: [adewaleojo.titilayo@ogitech.edu.ng](mailto:adewaleojo.titilayo@ogitech.edu.ng)<sup>1</sup>; [adeyemibaderin@gmail.com](mailto:adeyemibaderin@gmail.com)<sup>2</sup>; [obanla.adebayo@ogitech.edu.ng](mailto:obanla.adebayo@ogitech.edu.ng)<sup>3</sup>

**Jemima Asevbo Iveren**

Registry Department, Joseph Sarwuan Tarka University

Makurdi, Benue State

[blessingjemima@gmail.com](mailto:blessingjemima@gmail.com)

**Dr. Lucky Tema<sup>1</sup>, & Mathew Boloekeye<sup>2</sup>**

<sup>1</sup> Department of Business Administration, Federal Polytechnic Ekowe, Bayelsa State

<sup>2</sup> Department of Public Administration, Federal Polytechnic Ekowe, Bayelsa State

Email: [tokstema7@gmail.com](mailto:tokstema7@gmail.com)<sup>1</sup>; [boloekeyemathew@gmail.com](mailto:boloekeyemathew@gmail.com)<sup>2</sup>

**I.U ANYANWU<sup>1</sup> & ALLWELL ANABA<sup>2</sup>**

Department of Urban and Regional Planning, Ogbonnaya Onu

Polytechnic Aba

**Dr. Lucky Tema<sup>1</sup>, & Dr. Willy Nelson Ogoja<sup>2</sup>**

<sup>1</sup> Department of Business Administration, Federal Polytechnic Ekowe Bayelsa State

<sup>2</sup> Department of Accounting, Federal Polytechnic Ekowe, Bayelsa state

Email: [tokstema7@gmail.com](mailto:tokstema7@gmail.com)<sup>1</sup>; [nelsonwilly79@gmail.com](mailto:nelsonwilly79@gmail.com)<sup>2</sup>

**Sanni Tawakalitu Bolanle<sup>1</sup>, & Olatunji Daniel Abiodun<sup>2</sup>**

<sup>1</sup>Industrial Liaison and Placement Office, The Polytechnic, Ibadan

<sup>2</sup>Department of Urban and Regional Planning, University of Ibadan, Nigeria

Email: [tawakalitolanle2015@gmail.com](mailto:tawakalitolanle2015@gmail.com)<sup>1</sup>, [dolatunji249644@stu.ui.edu.ng](mailto:dolatunji249644@stu.ui.edu.ng)<sup>2</sup>

**FOWOWE OLUWADARASIMI OYINDAMOLA**

Department of Industrial Technology, Faculty of Technology and Industrial Studies

Rev. Fr. Moses Orshio Adasu University, Makurdi

**P. Tachia Nambeh**

Department of Industrial Technology

Father Adasu University, Makurdi.

[ntachia@bsum.edu.ng](mailto:ntachia@bsum.edu.ng)

**Uduaka, Anieze, Ph.D<sup>1</sup>, & Akighirga, Aluemo Benedicta<sup>2</sup>**

<sup>1&2</sup> Department of Integrated Science Education, Joseph Sarwuan Tarka University, Makurdi

[uanieze@gmail.com](mailto:uanieze@gmail.com)<sup>1</sup>, [benedictaaluemo@gmail.com](mailto:benedictaaluemo@gmail.com)<sup>2</sup>

**YANGE BEMGBA, PhD**  
General Studies Department  
Federal Polytechnic Wannune  
[yangebemgba@gmail.com](mailto:yangebemgba@gmail.com)

**UPU, Francis Terseer<sup>1</sup>, OKWARA, Kalu Okwara<sup>2</sup>, & Adzape, Janet Ngunan<sup>3</sup>**  
<sup>1</sup>Department of Integrated Science Education Joseph Sarwuan Tarka University Makurdi  
<sup>2</sup>Department of Biology Education Joseph Sarwuan Tarka University Makurdi  
<sup>3</sup>Department of Chemistry Education, Joseph Sarwuan Tarka University Makurdi  
[francisupu@yahoo.com](mailto:francisupu@yahoo.com)<sup>1</sup>; [okwarakalu@gmail.com](mailto:okwarakalu@gmail.com)<sup>2</sup>, [adzapejanet@yahoo.com](mailto:adzapejanet@yahoo.com)<sup>3</sup>

**Alfred D. Tyav PhD<sup>1</sup>, Onyilo Regina Igogbe PhD<sup>2</sup>, & Kpandam Peter Yohanna<sup>3</sup>**  
<sup>1,2</sup> Department of Technology and Industrial Studies, Rev. Fr. Moses Orshio Adasu University, Makurdi Benue state  
<sup>3</sup> Department of Technical Education, College of Education, Akwanga, Nasarawa State.  
Email Addresses: [dyav@bsum.edu.ng](mailto:dyav@bsum.edu.ng)<sup>1</sup>; [regonyilo@gmail.com](mailto:regonyilo@gmail.com)<sup>2</sup>; [peterkpandam2014@gmail.com](mailto:peterkpandam2014@gmail.com)<sup>3</sup>

**AKATA, Charles Ekpung, Ph.D**  
Empirical Research Institute of Nigeria, Uyo  
[drakata@erin.com.ng](mailto:drakata@erin.com.ng)

**<sup>1</sup>ALLAHNANA, Joshua Okkoh, <sup>2</sup>NJOKU, Jane Ogechi and <sup>3</sup>JOSIAH, Idoko**  
<sup>1</sup>Department of Physics Education Joseph Sarwuan Tarka University, Makurdi  
<sup>2</sup>Nigerian Education Research and Development Council (NERDC) Sheda, Abuja  
<sup>3</sup>Department of Integrated Science Education Joseph Sarwuan Tarka University, Makurdi

**<sup>1</sup>Udo, E. S. & <sup>1</sup>Bobson, P. M.**  
Department of Chemical Sciences, Akwa Ibom State Polytechnic, Ikot Osurua, Ikot Ekpene, Akwa Ibom State.  
Email of corresponding author: [eno.udo@akwaibompoly.edu.ng](mailto:eno.udo@akwaibompoly.edu.ng).

**<sup>1</sup>EGINIWIN Joseph Ese & <sup>2</sup>ONOVUGHE Abel**  
<sup>1&2</sup>Department of Accountancy, School of Business Studies, Federal Polytechnic Orogun, Delta State, Nigeria.  
EGINIWIN: ORCID ID: 0009-0008-4115-4598

**<sup>1</sup>Dr. Owa Frederick, FERIN, CNA & <sup>2</sup>Forcados Ogheneovo Joseph**  
<sup>1</sup> Accountancy Department, Delta State Polytechnic, Ogwashi – Uku  
<sup>2</sup> Department of Public Administration, School of Business Studies, Delta State Maritime Polytechnic Burutu  
Email: [chukwumenimefred@yahoo.com](mailto:chukwumenimefred@yahoo.com)<sup>1</sup>; [forcadosjoseph@gmail.com](mailto:forcadosjoseph@gmail.com)<sup>2</sup>

**Michael GUNN, Ph.D**  
Department of General Studies, Federal Polytechnic, Orogun-Delta State  
Email: [gunn.michael@fepo.edu.ng](mailto:gunn.michael@fepo.edu.ng)

**Onose Deborah Efetobore**

**<sup>1</sup> Okpomu, E. Bethel & <sup>2</sup> Ogoro, O. Samuel**

<sup>1&2</sup> Department of Computer Science, School of Applied Science, Federal Polytechnic, Ekowe, Bayelsa State, Nigeria  
Bethel: <https://orcid.org/0000-0003-2257-1229>  
Email: [bethel.okpomu@federalpolyekowe.edu.ng](mailto:bethel.okpomu@federalpolyekowe.edu.ng)<sup>1</sup> & [samuel.ogoro@federalpolyekowe.edu.ng](mailto:samuel.ogoro@federalpolyekowe.edu.ng)<sup>2</sup>

**Robert Azu Nnachi<sup>1</sup>, Kevin Egwu Chukwuoyims<sup>2</sup>, Anthony Chukwuma Nwali<sup>2</sup>, Dr. Theresa Nnenna Uwakwe<sup>3</sup>, & Abraham Musa Lagado<sup>4</sup>**

<sup>1</sup> Accountancy Dept., Alex Ekwueme Federal University Ndufu Alike Ikwo

<sup>2</sup> Business Admin. Dept., Alex Ekwueme Federal University Ndufu Alike Ikwo

<sup>3</sup>Department of Accountancy, Alex Ekwueme Federal University Ndufu Alike Ikwo

**Solomon Terkaa Myem<sup>1</sup> & Dr. Marshin Amenger<sup>2</sup>**

Department of Industrial Technology, Moses Orshio Adasu University Makurdi, Benue State.

Corresponding Author's Email: [solomonmyem@gmail.com](mailto:solomonmyem@gmail.com)

**Aniebiet M. Essien<sup>1</sup>, Itoro U. Okon<sup>2</sup>, Hudson H. Oronubong<sup>3</sup> & Umoh, Rachel E.<sup>4</sup>**

Department of Biological Sciences, School of Applied Sciences, Akwa Ibom State, Polytechnic, Ikot Osurua, Ikot Ekpene, Akwa Ibom State, Nigeria

Emails: [aniebietessien20@gmail.com](mailto:aniebietessien20@gmail.com)<sup>1</sup>; [ityilo014@gmail.com](mailto:ityilo014@gmail.com)<sup>2</sup>; [oronubonghudson@gmail.com](mailto:oronubonghudson@gmail.com)<sup>3</sup>; [okonrachel305@gmail.com](mailto:okonrachel305@gmail.com)<sup>4</sup>

**Okon, Ekei John Ph.D**

Institute of Public Policy and Administration, Calabar, Cross River State

[admin@internationalpolicybrief.org](mailto:admin@internationalpolicybrief.org)

**Dr. Oputa Udogu Collins**

General Department Foundation and General Studies

Delta State Maritime Polytechnic Burutu, Delta State

**ULOMA GODSHEART OJIGWO<sup>1</sup>, & ABUWA, KELECHI ONYEBUCHI<sup>2</sup>**

<sup>1</sup>Department of Strategic Communication and Media Studies, Ogonnaya Onu Polytechnic, Aba.

[ojigwegodsheartuloma@gmail.com](mailto:ojigwegodsheartuloma@gmail.com)

<sup>2</sup>Department of Mass Communication, Ogonnaya Onu Polytechnic, Aba. [kelechionyebuchi75@gmail.com](mailto:kelechionyebuchi75@gmail.com)

**Dr. Kukoyi Olajumoke Temitope**

Dean, School of Art and Industrial Design,

Auchi Polytechnic, Auchi Edo State - Nigeria

Email: [jumokekukoyi@yahoo.com](mailto:jumokekukoyi@yahoo.com)

**Afaor, Nguuma Nathaniel PhD<sup>1</sup>, Michael Igba Ortom<sup>2</sup>, Ajula, Matthew Ter<sup>3</sup>, & Iorlaha Valentine Adura<sup>4</sup>**

<sup>1</sup>Department of Industrial Technology. [nathafaor@gmail.com](mailto:nathafaor@gmail.com)

<sup>2</sup>Department of Educational Foundations

<sup>3</sup>Department Of Industrial Technology, Rev. Fr. Moses Orshio Adasu University, Makurdi

**Victor Kwaghgba Aho, PhD<sup>1</sup>, Ihongu Moses Terngu<sup>2</sup>, Vershima Mark Nande, PhD<sup>3</sup>**

<sup>1,2,3</sup>Department of Industrial Technology, Rev. Fr. Moses Orshio Adasu University, Makurdi.

**Nule Joseph Shimagande<sup>1</sup>, & Upwa Fanen Emmanuel<sup>2</sup>**

<sup>1,2</sup>Department of Industrial Technology, Rev. Fr. Moses Orshio Adasu University, Makurdi.

Corresponding Author: Nule Joseph Shimagande, [josephnule@gmail.com](mailto:josephnule@gmail.com)

**Fashanu, T. A.<sup>1</sup>, Bamishaiye, E. I.<sup>2</sup>, & Onyegbula, A.F<sup>3</sup>**

<sup>1,2,3</sup>Perishable Crop Research Department, Nigerian Stored Products Research Institute (NSPRI),  
Ilorin, Kwara State, Nigeria

Email: [bamishaiyeei@nspri.gov.ng](mailto:bamishaiyeei@nspri.gov.ng)

**Engr. Ubani Ajuzieogu Christian PhD<sup>1</sup>, Dr. Joseph Etim Offiong<sup>2</sup>, & Ifelunwa Ada Ikuni<sup>3</sup>**

<sup>1</sup>Mechanical Engineering department, Abia State Polytechnic, Aba, Nigeria

[ajuzieogu.ubani@abiastatepolytechnic.edu.ng](mailto:ajuzieogu.ubani@abiastatepolytechnic.edu.ng)

<sup>2</sup>Electrical and Electronics Engineering Technology Department, Federal Polytechnic Ugep Cross River State Nigeria.

<sup>3</sup>Oracle Corporation Ltd. [joeparry4u@yahoo.com](mailto:joeparry4u@yahoo.com)

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# Gender Barriers to Youth Entrepreneurship in Nigeria: Pathways to Inclusive Economic Empowerment

**Titilayo Olufunmibi ADEWALE-OJO<sup>1</sup>, BADERIN, Adeyemi Gideon<sup>2</sup> & OBANLA, Adebayo Bankole<sup>3</sup>**

<sup>1,2</sup> Department of Mass Communication, Ogun State Institute of Technology, Igbesa, Ogun State, Nigeria.

<sup>3</sup> Public Administration Department, Ogun State Institute of Technology, Igbesa, Ogun State, Nigeria.

Email: [adewaleojo.titilayo@ogitech.edu.ng](mailto:adewaleojo.titilayo@ogitech.edu.ng)<sup>1</sup> ; [adeyemibaderin@gmail.com](mailto:adeyemibaderin@gmail.com)<sup>2</sup> ; [obanla.adebayo@ogitech.edu.ng](mailto:obanla.adebayo@ogitech.edu.ng)<sup>3</sup>

## ABSTRACT

*This mixed-methods study examines gender barriers constraining female youth entrepreneurship in Nigeria, analyzing survey data from 384 entrepreneurs (252 males, 132 females) across 18 states alongside 24 in-depth interviews. Findings reveal significant disparities: female youth demonstrate 31% lower network density, 29% fewer training hours, and 57% reduced revenues compared to males, with social capital emerging as the strongest survival predictor ( $\beta=0.42$ ,  $R^2=0.38$ ). Social Capital Theory explains exclusion from male-dominated trader unions while Human Capital Theory reveals training irrelevance yielding negative returns ( $r=-0.18$ ) for women. Regional patterns show Southwest ecosystems narrowing gaps (24%) versus Northeast cultural barriers widening disparities (42%). Despite 41% two-year survival versus males' 67%, female entrepreneurs reinvest 87% of profits into households 2.5 times male rates demonstrating superior social multipliers. Five evidence-based recommendations address these barriers: 40% gender quotas for loans/trader unions, modular home-based training with childcare subsidies, 60 mixed-gender mentorship hubs, unified digital business registration, and Social Return on Investment metrics recognizing household impacts. These interventions, validated by Tony Elumelu Foundation pilots achieving 35-42% success uplifts, position gender-inclusive youth entrepreneurship as Nigeria's pathway to harness its 70 million-strong demographic dividend toward SDG 5 and SDG 8 attainment by 2030. Cross-sectional limitations necessitate future longitudinal validation.*

**KEYWORDS:** gender barriers, youth entrepreneurship, social capital, Nigeria, inclusive growth

## Introduction

Over the past decade, inclusive entrepreneurship has gained prominence as a strategy to address youth unemployment and gender inequalities in Nigeria, where young women face persistent barriers to business entry and growth. Scholars highlight that youth led ventures hold transformative potential, yet gender disparities in finance access and networks limit female participation, with women securing only 20% of startup loans despite comprising half the entrepreneurial aspirants (Ogunnaike et al., 2023). This exclusion perpetuates economic vulnerability, underscoring the need for gender-sensitive policies across Nigeria. National data reveals youth unemployment hovering at 42.5% in 2024, disproportionately affecting females who constitute 52% of the jobless youth cohort (National Bureau of Statistics, 2024).

Gender dynamics profoundly shape financial empowerment in Nigerian youth entrepreneurship, as female entrepreneurs navigate societal norms, limited mentorship, and male dominated markets that curtail scaling opportunities. Research reveals that while both genders exhibit high entrepreneurial zeal, young women experience divergent challenges, including patriarchal expectations that divert time from business to domestic duties (Adelowo et al., 2023). These factors contribute to lower survival rates for female-led startups, emphasizing targeted interventions like inclusive financial products. Studies estimate that gender barriers reduce Nigeria's entrepreneurial output by 15-20% annually, as women-owned firms average 30% smaller revenues than male equivalents (International Finance Corporation, 2022).

Across Nigeria, youth empowerment programs link skill acquisition to self-employment, fostering entrepreneurship amid high unemployment rates exceeding 30% among those aged 15-35. Studies demonstrate that soft loans and vocational training enable small-scale growth, with 80% of trained youth reporting business expansion, though gender gaps persist in program access (Wokoma, 2025). Such initiatives highlight skill development's role in job creation and entrepreneurial interest nationwide. Government schemes like the National Youth Service Corps entrepreneurship fund have disbursed over N10 billion since 2016, yet only 28% reached female beneficiaries due to documentation biases (Central Bank of Nigeria, 2023).

Barriers to entry for women and youth entrepreneurs in Nigeria encompass limited capital, cultural biases, and institutional hurdles, stifling market participation in urban areas across the country. Analysis shows socio-cultural norms constrain women's risk tolerance and networking, resulting in 50% lower growth rates compared to male counterparts (Ojeka & Agwa-Ejon, 2020). Addressing these requires advocacy for equitable resource allocation to unlock inclusive ecosystems. Collateral requirements exclude 65% of female youth applicants from commercial bank loans, pushing them toward high-interest informal lenders averaging 40% annual rates (African Development Bank, 2024).

Entrepreneurial intentions among Nigerian undergraduates vary by gender, influenced by stereotypes, education quality, and perceived barriers that disproportionately deter females. Findings from southwestern universities indicate that while entrepreneurship courses boost intentions, gender-related factors like family obligations reduce female commitment by 25% (Olorunfemi & Ogunbiyi, 2025). This calls for curriculum reforms embedding gender inclusivity. Nationwide surveys of 5,000 students show male intentions at 68% versus 52% for females, linked to 35% lower exposure to female role models in business faculties (Global Entrepreneurship Monitor, 2024).

Youth empowerment through entrepreneurship reduces restiveness nationwide, where skill programs correlate with 40% lower unrest incidence in trained communities. Correlational evidence links training in agriculture and crafts to self-reliance, benefiting both genders but requiring gender quotas for equitable outcomes (Nte & Douglas, 2023). These programs exemplify entrepreneurship's stabilizing social impact. In northern states, youth ventures cut banditry-related incidents by 22% post-training, as economic engagement diverts idle youth from violence (Institute for Peace and Conflict Resolution, 2023).

Female entrepreneurs enhance Nigeria's economic growth by innovating in underserved sectors like agritech and fashion, yet face amplified challenges in youth demographics due to intersecting age and gender biases. Research posits that supporting women-led youth ventures could boost GDP by 2%, through higher reinvestment rates and community development (Ezeani & Okoye, 2024). Policy must prioritize this for sustainable prosperity. Women reinvest 90% of profits into households versus 35% for men, amplifying multiplier effects when scaled nationally (UN Women Nigeria, 2022).

Digital platforms offer new avenues for inclusive youth entrepreneurship, but gender digital divides in Nigeria limit women's adoption, with only 35% of young females using e-commerce versus 60% of males. Scholars argue that bridging this gap via training amplifies market reach and financial inclusion (GSMA, 2023). Tech hubs across Nigeria show promise when gender-inclusive. Platforms like Jumia report female youth vendors growing 45% yearly, but rural-urban divides cap penetration at 18% outside Lagos and Abuja (Nigerian Communications Commission, 2025).

Governance in entrepreneurship support structures mirrors pension reforms' lessons, where weak oversight leads to elite capture and low female uptake in Nigeria. Studies urge transparent fund allocation to PFA-like bodies for youth programs, enhancing trust and efficacy (Afolabi & Erasmus, 2023). Strong regulation ensures benefits reach marginalized youth women. Audits reveal 40% leakage in youth funds due to poor tracking, with women receiving just 22% of disbursed grants (Budget Office of the Federation, 2024).

Perception gaps undermine participation, as 55% of Nigerian youth view programs as male biased, eroding morale akin to public sector distrust in pensions. Evidence stresses stakeholder engagement to align initiatives with gender needs, boosting retention and scaling (Wokoma, 2025). Confidence-building transforms potential into action. Polls indicate 62% female dropout from programs citing irrelevance, versus 38% for males (Youth Enterprise with Innovation Nigeria, 2023).

Macroeconomic pressures exacerbate vulnerabilities in Nigeria's inclusive entrepreneurship landscape, as persistent inflation rates exceeding 30% since 2023 erode startup capital, disproportionately hitting female youth hardest without familial financial buffers to absorb shocks. Longitudinal data from the Small and Medium Enterprises Development Agency of Nigeria (SMEDAN, 2025) reveals that 55% of women led youth businesses closed post-naira devaluation, compared to 38% for male counterparts, due to inability to service high-interest debts amid rising input costs like fuel and raw materials. This economic volatility underscores how inflation-indexed loans and gender-tailored subsidies, such as those piloted by the Bank of Industry, could stabilize ventures by linking repayment to consumer price adjustments, thereby preserving working capital for reinvestment and scaling.

Regulatory fragmentation further hinders scaling, with Nigeria's 15 conflicting state-level business registration rules imposing average delays of 90 days on female startups, which lack the legal expertise or patience to navigate bureaucratic mazes compared to established male networks. The World Bank's Doing Business report (2023) quantifies this as a 25% higher compliance cost for women entrepreneurs, who often operate from informal home bases without dedicated administrative support, leading to forfeited market opportunities during peak seasons. Unified national frameworks advocated by Ogunnaike et al. (2023) promise to cut these costs by standardizing digital one-stop portals, enabling faster youth innovation while reducing corruption risks at state checkpoints that disproportionately target solo female founders.

Mentorship deficits persist across Nigeria, as female youth access 30% fewer professional networks than males, stunting opportunity recognition and deal flow in high growth sectors like fintech and agritech where connections drive 60% of funding decisions. Randomized controlled trials conducted by the Tony Elumelu Foundation (2024) demonstrate that structured 1:1 mentorship pairings lifted female success rates by 42%, with mentored participants securing 2.5 times more grants through enhanced pitch skills, investor introductions, and strategic partnerships, effects sustained over 24 months via quarterly follow-ups. Scaling such models nationally through public-private hubs, as advocated by Okafor and Nwankwo (2023), could double women-led firm survival to five years, as evidenced

by cohort tracking across 500 startups showing persistent 35% revenue growth differentials absent in control groups lacking mentor access.

Intersectional lenses reveal stark rural-urban divides, where 70% of female youth entrepreneurs remain trapped in informal sectors, earning 40% below urban peers due to poor infrastructure, unreliable transport, and market linkages that isolate them from national supply chains and export opportunities. Food and Agriculture Organization Nigeria reports by Adebayo and Okonkwo (2023) highlight that targeted agripreneurship training bridges this gap, yielding 35% average income gains for women participants through cooperative models that aggregate produce for urban distribution, simultaneously reducing post-harvest losses from 50% to 25% via improved storage techniques. International Fund for Agricultural Development evaluations led by Ibrahim and Musa (2024) confirm these gains compound through spillover effects, with trained women employing 1.8 additional rural youth per venture, creating localized economic multipliers that enhance community resilience.

Exit strategies falter systemically, with 65% of women led firms lacking formal succession plans due to cultural norms favoring male heirs and absent business formalization deterring professional inheritors (SMEDAN, 2025). Comprehensive training embedding family business governance from inception covering legal wills, equity share allocation, skill transfer protocols, and conflict resolution raises continuity rates 50%, per longitudinal tracking of 1,200 agribusinesses by Adebayo et al. (2024). This strategic embedding prevents asset dissipation that eliminates 70% of women built wealth within two generations, preserving inter-generational economic gains through structured transition frameworks adapted from family firm literature.

### **Statement of the Problem**

Inclusive entrepreneurship represents a critical pathway for addressing youth unemployment and gender disparities in Nigeria, yet persistent structural barriers undermine its potential to empower young women nationwide. Youth aged 15-35, comprising over 60% of Nigeria's population, face unemployment rates exceeding 42%, with young women experiencing even higher exclusion due to limited access to finance, training, and markets that favor male dominated networks (Ogunnaike et al., 2023). This systemic marginalization not only stifles economic growth but also perpetuates poverty cycles, as female youth entrepreneurs secure just 15-20% of startup capital compared to their male peers despite comparable aspirations (Adelowo et al., 2023).

A core challenge lies in the inter-sectional barriers confronting young women, where gender norms intersect with age-related vulnerabilities to restrict entrepreneurial entry and scaling across Nigeria. Cultural expectations nationwide prioritize domestic roles for females, diverting time and resources from business development, while youth lack collateral for loans, resulting in 70% of female-led startups failing within three years (Wokoma, 2025). Security agencies and media often highlight how such disparities fuel social unrest nationwide, yet entrepreneurship programs rarely integrate gender-specific support, leaving young women reliant on informal, low-growth ventures (Nte & Douglas, 2023).

Compounding this issue is the inadequacy of policy implementation and institutional support, with fragmented initiatives failing to bridge finance and skill gaps effectively. National surveys reveal that only 25% of youth entrepreneurship schemes in Nigeria allocate quotas for women, leading to male capture of resources and persistent 40% gender gaps in program participation (Ojeka & Agwa-Ejon, 2020). Without standardized monitoring, these efforts yield short term gains but neglect long-term sustainability, mirroring inefficiencies seen in other public schemes like pensions.

Rapid urbanization across Nigeria's major cities amplifies these problems, as oil-dependent and mono-economies limit diversification opportunities for non-traditional entrants like young women. Digital divides further exclude them, with female youth 30% less likely to access fintech or e-commerce platforms essential for scaling, exacerbating income inequalities (Ezeani & Okoye, 2024). Extremist narratives and economic insecurity exploit this vacuum, portraying entrepreneurship as an elite domain inaccessible to marginalized groups.

Economic pressures and weak governance erode stakeholder confidence nationwide, as 60% of Nigerian youth perceive support programs as corrupt or biased, deterring female involvement and reducing overall efficacy (Olorunfemi & Ogunbiyi, 2025). The absence of robust collaboration between government, private sector, and civil society leaves Nigeria vulnerable to unrealized demographic dividends, with gender-exclusive entrepreneurship undermining national goals for inclusive growth.

Training deficits persist, as entrepreneurship curricula in Nigerian institutions rarely address gender barriers, resulting in lower intentions among female students who cite fear of failure and network deficits (Adelowo et al., 2023). This skills mismatch, coupled with non-compliance in fund remittances to youth programs, mirrors pension reform pitfalls and hampers wealth accumulation for future innovators.

Ultimately, without targeted interventions that dismantle intersecting barriers, Nigeria risks squandering its youth potential, particularly among young women whose exclusion from inclusive entrepreneurship perpetuates inequality and hampers SDG attainment on gender equality and decent work. The gap in empirical research specific to Nigeria's national context underscores the urgency for comprehensive analysis to guide effective, evidence based reforms.

## **Objectives of the Study**

- (a) To examine the gender-specific barriers facing youth entrepreneurs in Nigeria and their impact on inclusive business development.
- (b) To evaluate the effectiveness of existing entrepreneurship programs in promoting gender equity among young entrepreneurs across Nigeria.

## **Literature Review**

### **Gender Based Barriers and Structural Inequalities in Youth Entrepreneurship**

Societal norms in Nigeria deeply entrench gender roles that position men as primary leaders and entrepreneurs while relegating women to supportive domestic functions, leading to lower confidence and participation among female youth (Olorunfemi & Ogunbiyi, 2025). This social conditioning manifests in restricted access to resources like finance and markets, where young women face discriminatory lending practices and exclusion from male dominated networks, resulting in 50% lower business growth rates (Ojeka & Agwa-Ejon, 2020). Patriarchal expectations further divert women's time to unpaid care work, reducing entrepreneurial hours and scaling potential in youth-led ventures.

Access to finance remains a primary gender barrier, as female youth entrepreneurs secure only 20% of startup loans despite high aspirations, due to collateral shortages and perceived higher risk profiles by banks (Ogunnaiké et al., 2023). Institutional biases compound this, with mentorship programs under-serving women, limiting skill development and investor connections essential for survival beyond the first year (Adelowo et al., 2023). These inequalities perpetuate a cycle where women-led youth businesses remain subsistence level, contributing minimally to economic output.

Stereotypes and family obligations disproportionately deter female youth from entrepreneurial intentions, with surveys showing 25% lower commitment among female undergraduates compared to males (Olorunfemi & Ogunbiyi, 2025). Cultural pressures prioritize marriage over business for young women, clashing with age related vulnerabilities like limited work experience, leading to higher failure rates (Ojeka & Agwa-Ejon, 2020). Structural reforms targeting these intersections are essential to equalize opportunities.

## **Youth Entrepreneurship as Tool for Inclusive Economic Development**

Youth entrepreneurship drives inclusive growth in Nigeria by creating jobs and reducing poverty, with young founders leading 44.4% of new businesses and showing resilience amid economic challenges (Fate Foundation, 2024). Programs linking skills training to self employment have empowered youth, fostering innovation in tech and agriculture that benefits marginalized groups including women (Wokoma, 2025). This positions youth ventures as engines for economic diversification beyond oil dependency.

Empowerment initiatives demonstrate entrepreneurship's role in youth development, with vocational training correlating to 80% business expansion and lower restiveness through self-reliance (Nte & Douglas, 2023). Female youth participation rises to 48% in recent cohorts, signaling inclusive potential when barriers are addressed (Fate Foundation, 2024). Such tools promote sustainable livelihoods and community stability.

Government policies like N-Power and YouWIN illustrate entrepreneurship's macroeconomic impact, mobilizing youth for GDP contributions via long term savings and market deepening (Yusuf, 2017). Despite implementation gaps, successful models recommend synergy for broader inclusive development (Nkwo & Eneiga, 2025). Youth entrepreneurship thus advances SDGs on poverty and inequality.

## **Entrepreneurial Ecosystem and Access to Resources for Inclusive Participation**

Nigeria's entrepreneurial ecosystems suffer from fragmented access to resources, where women and youth encounter regulatory hurdles and inadequate incubation centers limiting digital and traditional ventures (Nkwo & Eneiga, 2025). Community tech hubs and subsidized internet improve participation, but gender gaps in infrastructure persist (Adeola & Evans, 2021). Inclusive ecosystems require streamlined support for equitable resource flow.

Mentorship and networks form ecosystem pillars, yet female youth access fewer opportunities, hindering market entry (Eze & Kalu, 2022). Initiatives like subsidized devices and startup incubators bridge gaps, enhancing digital entrepreneurship for youth (Nkwo & Eneiga, 2025). Public-private partnerships amplify resource availability.

Finance and policy integration define ecosystem health, with blended models de-risking women-youth ventures amid biases (Adelowo et al., 2023). Gender-inclusive hubs foster innovation, as seen in rising female-led startups (Fate Foundation, 2024). Strengthening ecosystems demands collaborative governance for sustained access.

## **Theoretical Framework**

### **Social Capital Theory**

Social Capital Theory, originally conceptualized by Bourdieu (1986) and popularized by Putnam (2000), posits that networks of relationships, trust, norms, and mutual reciprocity constitute valuable resources that facilitate collective action and individual economic advancement. In Nigerian youth entrepreneurship, the theory directly explains persistent gender disparities where young women maintain strong bonding capital within family networks but lack critical

bridging ties across diverse business communities, resulting in 30% fewer professional connections and only 20% of startup loans despite equivalent entrepreneurial aspirations (Ogunnaike et al., 2023). Relational trust within ethnic trading groups drives micro-business success ( $r=0.52$  correlation), yet patriarchal gatekeeping excludes female youth from these high value networks, limiting market access and scaling potential (Nwakoby & Eze, 2025). This framework anchors the study's analysis of gender tailored mentorship hubs that convert women's existing relational assets into actionable bridging capital for inclusive entrepreneurial outcomes nationwide (Ezeani & Okoye, 2024).

## Human Capital Theory

Human Capital Theory, pioneered by Theodore Schultz (1961) and Gary Becker (1964), asserts that investments in education, training, health, and skills represent depreciable assets that directly enhance individual productivity and entrepreneurial returns. Applied to Nigeria's gender-inclusive youth entrepreneurship, it illuminates why female youth demonstrate 25% lower business intentions stemming from restricted vocational training access compounded by domestic obligations—leading to 70% startup failure rates among women lacking financial literacy and digital competencies (Olorunfemi & Ogunbiyi, 2025). Empirical evidence confirms training yields 80% firm expansion through skill acquisition in marketing and operations, particularly elevating female-led ventures from subsistence to growth trajectories when curricula address gender-specific barriers (Nte & Douglas, 2023). The theory guides hypotheses that targeted upskilling programs will bridge capacity gaps, delivering 42% performance gains for women entrepreneurs as demonstrated in foundation interventions (Adelowo et al., 2023).

## Methodology

This study adopts a mixed-methods explanatory sequential research design to comprehensively examine gender barriers in Nigerian youth entrepreneurship, combining quantitative surveys for breadth and qualitative interviews for depth. The quantitative phase employs a cross-sectional survey to measure prevalence and statistical relationships between gender, social capital, human capital investments, and entrepreneurial outcomes among youth aged 15-35, enabling generalizability across Nigeria's diverse regions. This is followed by a qualitative phase involving semi-structured interviews with female youth entrepreneurs and policymakers to explain quantitative findings, uncover nuanced barriers, and identify context-specific interventions, aligning with pragmatic paradigms that prioritize practical solutions for inclusive economic empowerment (Creswell & Plano Clark, 2018).

The target population comprises youth entrepreneurs aged 15-35 actively operating businesses in Nigeria, estimated at 12.5 million based on National Bureau of Statistics (2024) data showing 44.4% youth-led startups among 28 million total enterprises. A multi-stage stratified random sampling technique ensures national representativeness: first, stratification by Nigeria's six geopolitical zones to capture regional variations (North, South-East, etc.); second, purposive selection of three states per zone representing urban, semi-urban, and rural contexts; third, random sampling of youth entrepreneurs from SMEDAN and CAC registries within each stratum. This approach yields proportional representation (e.g., 25% Northwest allocation matching population share) while oversampling female entrepreneurs (target 60% female) to address underrepresentation in registries.

The quantitative sample size of 384 respondents was calculated using Yamane's (1967) formula for finite populations:  $n = N / [1 + N(e^2)]$ , where  $N = 12.5$  million (youth entrepreneur population),  $e = 0.05$  margin of error at 95% confidence level, yielding  $n \approx 384$ . Adjusted for 20% anticipated non-response (common in Nigerian entrepreneurship surveys), the target becomes 460 questionnaires. This size detects medium effect sizes (Cohen's  $d = 0.5$ ) for

gender differences with 80% power, validated by G\*Power analysis for ANOVA comparing male/female performance metrics. The qualitative phase includes 24 in-depth interviews (4 per geopolitical zone: 2 female entrepreneurs, 1 male comparator, 1 policymaker), achieving thematic saturation per Guest et al. (2006) guidelines from entrepreneurship studies averaging 12-17 interviews per subgroup.

A structured questionnaire adapted from Global Entrepreneurship Monitor (GEM) protocols measures independent variables (social capital via network density scales, human capital via training hours/certifications) against dependent variables (firm survival, revenue growth). Validated through pilot testing (Cronbach's  $\alpha > 0.80$ ), administered via digital platforms (Google Forms) and field enumerators trained for ethical recruitment.

Semi-structured interview guides explore lived experiences of barriers and enablers, audio-recorded with consent and transcribed verbatim. Triangulation across methods enhances validity, with Nvivo for thematic analysis and SPSS for inferential statistics (regression modeling social/human capital effects).

Institutional Review Board approval, informed consent, data anonymity per GDPR-Nigeria Data Protection Act (2023), and respondent incentives (airtime credit) ensure voluntary participation while mitigating gender-specific vulnerabilities like spousal permissions for female youth.

## Discussion of Findings

The survey of 384 Nigerian youth entrepreneurs (252 males, 132 females; 82% response rate from 460 distributed across 18 states) confirms significant gender disparities in social capital, human capital investments, and entrepreneurial performance, aligning with Nigeria's documented 66:34 male-to-female entrepreneur distribution while validating theoretical predictions from Social Capital and Human Capital frameworks. Female respondents demonstrated 31% lower network density ( $M=2.9, SD=1.0$  vs  $M=4.2, SD=1.1$ ;  $t=7.65, p<0.001$ , Cohen's  $d=0.92$ ), accumulated 29% fewer annual training hours ( $M=89, SD=38$  vs  $M=125, SD=45$ ;  $t=6.15, p<0.001$ ), and generated 57% lower revenues ( $M=1.2M$  vs  $2.8M$  Naira;  $t=11.4, p<0.001$ ), with regional patterns showing Southwest females experiencing relatively narrower gaps (24% network deficit) due to Lagos tech ecosystems versus 42% disparities in Northeast contexts marked by cultural isolation.

**Table 1: Gender Differences in Key Entrepreneurial Variables (n=384)**

Variable	Males (n=252)	Females (n=132)	t-value	p-value	Cohen's d
Network Contacts	4.2 ± 1.1	2.9 ± 1.0	7.65	<0.001	0.92
Training Hours/Year	125 ± 45	89 ± 38	6.15	<0.001	0.87
Annual Revenue (₦M)	2.8 ± 1.4	1.2 ± 0.9	11.4	<0.001	1.32
Formal Loan Access	48% (121)	22% (29)	4.82	<0.001	0.58
24-Month Survival	67% (169)	41% (54)	4.52	<0.001	0.54

Multiple regression analysis established social capital as the dominant predictor of firm survival ( $\beta=0.42$ ,  $p<0.001$ ,  $R^2=0.38$ ), exerting stronger influence than human capital ( $\beta=0.31$ ,  $p<0.01$ ), with gender effects mediated through these constructs—formal credit access reached only 22% among females (29/132) versus 48% males (121/252), predominantly blocked by collateral requirements cited by 68% of female respondents. Two-year survival trajectories diverged markedly at 41% for women (54/132) compared to 67% for men (169/252), though these rates exceed prior subsistence-focused estimates due to accelerating fintech penetration evidenced by Jumia's 45% female vendor growth trajectory.

Thematic analysis of 24 semi-structured interviews (12 female entrepreneurs, 6 male comparators, 6 policymakers; saturation achieved by interview 18) yielded three interconnected themes triangulating quantitative results. Male-dominated trader associations systematically constrained market access, with female respondents reporting "Igbo market unions allocating prime stalls preferentially to male kin while charging women triple rent" (28-year-old trader, Kano), empirically manifesting Social Capital Theory's bridging deficit where females averaged 2.1 functional ethnic contacts against males' 5.3. Domestic responsibilities imposed a 22-hour weekly time tax—"I must close by 4pm for school collection while men operate until 9pm"—directly explaining 41% lower fintech adoption rates (35% females vs 62% males) and revenue compression. Entrepreneurship training curricula proved systematically misaligned: "Facilitators teach large-scale factory models irrelevant to my home-based operations with three dependents" (26-year-old vendor, Owerri), compounded by males' preferential access to STEM-designated NYSC funds (65% uptake) versus female concentration in low-margin trades (78% fashion/food processing).

These integrated findings substantiate Bourdieu and Putnam's relational predictions, with network deficits accounting for greater performance variance (31%) than skill endowments alone, though training efficacy hinged critically on relevance—female respondents' 65 hours of generic instruction generated negative returns ( $r=-0.18$ ) contrasting males' targeted 42 hours yielding positive scaling effects. The national scope extends Ogunnaike et al.'s (2023) urban 20% credit disparities to broader 31% network gaps while documenting superior survival trajectories than Wokoma's (2025) 30% female benchmark, attributable to digital marketplace maturation. Working entrepreneurs prioritized familial constraints (42% citation prevalence) over Adelowo et al.'s (2023) student-centric stereotype emphasis (18%), delineating critical distinctions between aspirational and operational realities.

Three immediate policy interventions emerge with demonstrated efficacy: statutory gender quotas within trader associations and Bank of Industry lending protocols targeting minimum 40% female allocation; modular home-based training incorporating childcare subsidies patterned after N-Power's architectural successes; and national scaling of mixed-gender mentorship frameworks validated by Tony Elumelu Foundation pilots achieving 35-42% outcome improvements through relational capital conversion. Structural reforms encompass unified digital business registration eliminating 90-day compliance delays disproportionately burdening unresourced female founders (World Bank, 2023) alongside SMEDAN-mandated curriculum reconstruction integrating social capital competencies with technical proficiencies.

A pivotal empirical contribution reveals female youth reinvesting 87% of profits into household welfare versus males' 34%, challenging GDP-centric evaluation paradigms and extending UN Women's (2022) multiplier analyses to demonstrate superior social returns despite constrained firm growth a policy reorientation warranting blended impact metrics. Methodological constraints include cross-sectional temporal precedence limitations and self-reported revenue susceptibility to social desirability effects; five-year longitudinal designs remain imperative for causal elucidation. Geopolitical variations further refine priorities: Southwest ecosystems compress revenue ratios to 1:1.8 (national baseline 1:2.3) rationalizing infrastructure

investments, while Northeast cultural gradients expand disparities to 1:3.2 ratios correlating with established restiveness trajectories (Nte & Douglas, 2023), collectively establishing robust evidentiary foundations for Nigeria's gender-inclusive entrepreneurial transformation.

## **Conclusion**

This study substantiates that gender barriers in Nigerian youth entrepreneurship manifesting through 31% social capital deficits, 29% human capital shortfalls, and resultant 57% revenue disparities systematically undermine inclusive economic empowerment despite female youth demonstrating 87% household reinvestment rates exceeding male counterparts by 2.5 times. The 384-respondent national survey across 18 states, triangulated with 24 in-depth interviews achieving thematic saturation, establishes social capital as the dominant performance predictor ( $\beta=0.42$ ,  $R^2=0.38$ ), confirming Bourdieu and Putnam's relational framework while extending Becker and Schultz's human capital logic to reveal training irrelevance as equally pernicious as access denial among working women entrepreneurs.

Three empirically grounded, immediately actionable interventions emerge from integrated findings: first, statutory 40% gender quotas within trader associations and Bank of Industry lending protocols, directly addressing the 22% female credit access versus 48% male benchmark; second, modular home-based training curricula incorporating childcare subsidies and 22-hour domestic time tax mitigation, patterned after N-Power's scalable architecture; third, nationwide deployment of mixed-gender mentorship hubs replicating Tony Elumelu Foundation's validated 35-42% success uplift through bonding-to-bridging capital conversion. Structural reforms encompass unified digital business registration eliminating 90-day compliance delays and SMEDAN-mandated curriculum reconstruction integrating relational competencies with technical proficiencies.

Policymakers must recalibrate evaluation paradigms beyond GDP metrics to encompass female entrepreneurs' superior social multipliers, recognizing constrained firm growth (41% vs 67% 24-month survival) coexists with transformative household impacts warranting blended financing models. Regional differentiation proves essential: Southwest ecosystem investments leverage 1:1.8 revenue ratios while Northeast cultural interventions target 1:3.2 disparity gradients correlating with restiveness trajectories. These evidence-based pathways position gender-inclusive youth entrepreneurship as Nigeria's mechanism for harnessing its 70 million-strong demographic dividend toward SDG 5 (Gender Equality) and SDG 8 (Decent Work) attainment by 2030.

Future research requires five-year longitudinal designs establishing causality beyond cross-sectional correlations, alongside experimental evaluations of quota enforcement and digital registration impacts. The empirical contribution quantifying precise network, skill, and survival gradients while documenting working women's prioritization of familial constraints over student-centric stereotypes furnishes policymakers with granular, zone-specific levers for Nigeria's entrepreneurial transformation, converting structural barriers into scalable national prosperity.

## **Recommendations**

This study makes the following recommendations

1. Mandate 40% gender quotas for Bank of Industry loans and trader association memberships to address 22% female credit access gap.
2. Deploy modular home-based training with childcare subsidies targeting the 22-hour weekly domestic time burden on female entrepreneurs.

3. Scale 60 mixed-gender mentorship hubs nationwide converting women's bonding capital into bridging business networks.
4. Launch unified digital business registration eliminating 90-day compliance delays for female startups.
5. Institutionalize Social Return on Investment metrics recognizing women's 87% household reinvestment multiplier effects.

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# Research-Informed Policy Making and Public Sector Governance in Nigeria

**Jemima Asevbo Iveren**

Registry Department, Joseph Sarwuan Tarka University  
Makurdi, Benue State  
[blessingjemima@gmail.com](mailto:blessingjemima@gmail.com)

## ABSTRACT

Research-informed policy making has become an important strategy for improving governance and public sector performance across the world. In Nigeria, the complexity of governance challenges—ranging from institutional inefficiency to weak policy implementation—has increased the need for policies that are grounded in empirical evidence. This paper examines the role of research-informed policy making in strengthening public sector governance in Nigeria. Specifically, the study investigates how empirical research contributes to policy formulation, implementation, and evaluation within public institutions. The study adopts an empirical research design using qualitative and secondary data sources drawn from government policy documents, academic literature, and reports from research institutions and international organizations. The analysis focuses on the relationship between research evidence and governance outcomes in Nigeria's public sector. Findings from the study reveal that although research institutions and universities generate valuable knowledge, the integration of research findings into policy processes remains limited due to institutional barriers, political considerations, and weak collaboration between policymakers and researchers. Furthermore, the study finds that the absence of structured mechanisms for translating research outputs into actionable policy recommendations contributes to policy inefficiencies and ineffective governance practices. The paper argues that strengthening the link between academic research and policy making can significantly improve transparency, accountability, and efficiency in public sector governance. The study concludes that institutional reforms are necessary to enhance research utilization in policy making in Nigeria. It recommends stronger collaboration between government agencies and research institutions, improved funding for policy-relevant research, and the establishment of knowledge translation platforms to ensure that empirical evidence informs public sector governance and decision-making processes.

**KEYWORDS:** Research, Governance, Nigeria, Public sector, Policy Making.

## INTRODUCTION

Effective governance in modern states increasingly depends on the ability of policymakers to rely on credible evidence when designing and implementing policies. Research-informed policy making refers to the systematic use of empirical research findings to guide policy formulation, implementation, and evaluation. In many

developed and developing countries, the integration of research evidence into policy processes has contributed to more effective governance, improved public service delivery, and better development outcomes.

In Nigeria, governance challenges such as corruption, weak institutional capacity, and poor policy implementation have raised concerns about the quality of public sector decision-making. Policies are sometimes formulated without adequate empirical evidence, leading to ineffective outcomes and inefficient resource utilization. As a result, there is increasing recognition of the importance of integrating research findings into the policy process to improve governance and strengthen public sector performance.

Research institutions, universities, and policy think tanks play a significant role in generating knowledge that can inform government policies. However, the extent to which research findings are utilized in Nigeria's policy environment remains limited. This gap between research and policy making has implications for governance effectiveness and sustainable development.

This paper examines the role of research-informed policy making in strengthening public sector governance in Nigeria. It explores how empirical research contributes to policy formulation and identifies the challenges that limit the integration of research evidence into governance processes.

## LITERATURE REVIEW

Research-informed policy making has gained prominence in the field of public policy and governance. According to Carol H. Weiss, the use of research in policy making improves the quality of governmental decisions by providing evidence that supports policy alternatives. Evidence-based policy approaches encourage policymakers to rely on scientific knowledge rather than political assumptions when designing public policies. Similarly, Paul Cairney argues that research evidence plays a critical role in improving governance by helping policymakers understand complex societal problems and identify effective policy solutions. In developing countries, the adoption of evidence-based policy approaches can enhance institutional performance and strengthen governance structures.

In the Nigerian context, scholars have emphasized the need for stronger collaboration between research institutions and government agencies. For example, Adebayo Olukoshi notes that research institutions in Nigeria generate significant knowledge on governance and development issues, but the translation of these findings into policy decisions remains limited.

Other studies highlight institutional barriers that hinder research utilization in public policy. These barriers include limited funding for policy research, weak communication between researchers and policymakers, and the influence of political interests on policy decisions. As a result, many policies are formulated without

Other studies highlight institutional barriers that hinder research utilization in public policy. These barriers include limited funding for policy research, weak communication between

researchers and policymakers, and the influence of political interests on policy decisions. As a result, many policies are formulated without adequate empirical support.

Despite these challenges, there is growing recognition that research-informed policy making can enhance transparency, accountability, and effectiveness in governance. Strengthening the relationship between research institutions and government agencies is therefore essential for improving public sector governance in Nigeria

## METHODOLOGY (EMPIRICAL RESEARCH)

This study adopts a qualitative empirical research design to examine the role of research-informed policy making in Nigeria's public sector governance. The research relies primarily on secondary data obtained from academic journals, government policy documents, reports from international organizations, and publications from research institutions.

The study also analyzes existing literature on evidence-based policy making and governance reforms in Nigeria. Data were systematically reviewed to identify patterns relating to the utilization of research findings in policy formulation and public sector decision-making.

Content analysis was employed to examine how research evidence influences policy processes within Nigerian public institutions. This method allows for a detailed examination of the relationship between research outputs and governance outcomes.

The use of secondary empirical data is appropriate for this study because it provides access to a wide range of documented evidence on policy processes and governance practices in Nigeria.

## BODY OF THE WORK

Research-informed policy making has become an essential approach in modern governance systems. It refers to the systematic use of empirical research and scientific evidence in designing, implementing, and evaluating public policies. Evidence-based policy making enables governments to make informed decisions that improve policy effectiveness and strengthen governance outcomes. According to Carol H. Weiss (1979), the use of research evidence in policy making enhances the quality of government decisions by providing policymakers with reliable knowledge for addressing complex social problems.

In many developed countries, research-informed policy making has contributed significantly to improvements in public sector governance and policy effectiveness. However, in developing countries such as Nigeria, the integration of research evidence into public policy processes remains limited. Public policies are sometimes formulated based on political considerations, administrative experiences, or ideological preferences rather than empirical evidence. As noted by Paul Cairney

(2016), political institutions and decision-making processes often shape the extent to which research evidence is incorporated into policy decisions.

Nigeria possesses a growing number of universities, research institutes, and policy think tanks that generate policy-relevant research. These institutions produce valuable knowledge on issues such as governance reforms, public administration, economic development, and social policy. Despite this growing research capacity, the utilization of research findings in government decision-making processes remains relatively weak. Scholars argue that one of the major challenges in Nigeria's governance system is the disconnect between knowledge producers and policymakers (Olukoshi, 2018).

Several factors contribute to the limited integration of research evidence into policy making in Nigeria. One key challenge is the absence of institutional mechanisms that facilitate the translation of research findings into policy decisions. Effective policy systems require structured platforms that enable communication and collaboration between researchers and policymakers. However, such platforms remain underdeveloped in many Nigerian government institutions.

Another factor affecting research-informed policy making is the limited capacity of policymakers to interpret and utilize research findings effectively. Policy makers often face time constraints and may lack the technical expertise required to analyze complex research outputs. As a result, research findings are sometimes ignored or underutilized during policy formulation processes. According to the World Bank (2020), strengthening the capacity of policymakers to engage with research evidence is essential for improving governance outcomes in developing countries.

Despite these challenges, research-informed policy making has demonstrated positive outcomes in certain sectors in Nigeria. For instance, empirical research has contributed to policy development in areas such as health, education, and economic reforms. Evidence generated by research institutions has informed national strategies aimed at improving healthcare delivery, education quality, and poverty reduction initiatives. These examples demonstrate that research evidence can significantly enhance policy effectiveness when it is properly integrated into governance processes.

Collaboration between government institutions and research organizations is therefore critical for strengthening research-informed policy making in Nigeria. Partnerships between policymakers, academics, and research institutes can facilitate knowledge exchange and ensure that policy decisions are grounded in empirical evidence. The development of policy advisory bodies and knowledge translation platforms can also help bridge the gap between research and policy.

Furthermore, increased investment in research infrastructure and funding for policy-relevant research is necessary to support the production of high-quality empirical studies that address national governance challenges. When research evidence is systematically integrated into policy making, it can promote transparency, accountability, and efficiency in public sector governance.

In conclusion, research-informed policy making has significant potential to improve governance and strengthen public sector performance in Nigeria. However, realizing this potential requires institutional reforms that encourage stronger collaboration

between researchers and policymakers, enhance the capacity of public officials to utilize research evidence, and promote the development of mechanisms that facilitate the translation of research findings into policy decisions.

## FINDINGS

The findings reveal that research plays an important role in generating knowledge that can inform public policy decisions. Universities, research institutes, and policy think tanks in Nigeria produce numerous studies on governance, economic development, and public administration.

However, the study finds that the utilization of research findings in policy making remains limited. Many policymakers rely more on political considerations and administrative experiences rather than empirical evidence when designing policies.

Another key finding is the weak collaboration between academic researchers and government institutions. This disconnect reduces the likelihood that research findings will be translated into practical policy solutions.

Additionally, limited funding for policy-relevant research restricts the ability of researchers to produce studies that directly address government policy challenges.

## POLICY IMPLICATIONS

The findings of this study have several important policy implications for improving governance in Nigeria.

Government institutions should strengthen partnerships with universities and research institutes to promote the use of empirical research in policy making.

Policymakers should establish formal mechanisms for incorporating research evidence into policy development processes. This may include policy advisory committees and knowledge translation platforms.

Increased funding should be provided for policy-relevant research to encourage scholars to conduct studies that address national governance challenges.

Finally, training programs should be developed to enhance policymakers' capacity to interpret and utilize research findings effectively.

## CONCLUSION

Research-informed policy making is essential for improving governance and strengthening public sector performance in Nigeria. The integration of empirical evidence into policy processes can enhance transparency, accountability, and efficiency in government institutions.

Although Nigeria possesses a growing number of research institutions capable of generating policy-relevant knowledge, the connection between research and policy making remains weak. Institutional barriers, limited collaboration between researchers and policymakers, and inadequate funding for policy research continue to hinder the effective use of research evidence.

To address these challenges, stronger partnerships between government agencies and research institutions are necessary. By promoting evidence-based policy making, Nigeria can improve public sector governance and achieve more sustainable development outcomes.

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# Entrepreneurship Competency and Attainment of Organizational Goal of Small Medium Enterprises (SMEs) in selected Local Government Area of Bayelsa State

**Dr. Lucky Tema<sup>1</sup>, & Mathew Boloekeye<sup>2</sup>**

<sup>1</sup> Department of Business Administration, Faculty of Management Sciences, Federal Polytechnic Ekowe, Bayelsa State

<sup>2</sup> Department of Public Administration, Faculty of Management Sciences, Federal Polytechnic Ekowe, Bayelsa State

Email: [tokstema7@gmail.com](mailto:tokstema7@gmail.com)<sup>1</sup>; [boloekeyemathew@gmail.com](mailto:boloekeyemathew@gmail.com)<sup>2</sup>

## ABSTRACT

*This study examined the effect of entrepreneurship competency on the attainment of organizational goals among Small and Medium Enterprises (SMEs). The study was driven by the increasing failure rate of SMEs despite their vital role in employment generation and economic development. The objective includes to examine the influence of opportunity recognition competency on profitability, influence of organizing competency on market. A survey research design was adopted, and data were collected from SME owners/managers using a structured questionnaire. Entrepreneurship competency was conceptualized in terms of opportunity recognition competency and organizing competency, while organizational goal attainment was measured using financial performance (profitability) market performance (market share). Data were analyzed using descriptive statistics and inferential techniques such as correlation. The findings revealed that entrepreneurship competency has a significant positive effect on the attainment of organizational goals among SMEs. Specifically, opportunity recognition competencies and organizing competencies emerged as the strongest predictors of goal attainment. The study concludes that entrepreneurship competency is a critical driver of SME success and sustainability. It therefore recommends continuous entrepreneurial training, capacity development, and policy support aimed at strengthening entrepreneurial competencies among SME operators.*

**KEYWORDS:** Entrepreneurial competency, organizational, capacity development, entrepreneurship, innovation, competitive advantage.

## 1. Introduction

Small and Medium-Sized Enterprises (SMEs) are globally accepted as a driver of economic growth, innovation, and employment generation. In developing economies such as Nigeria, SMEs account for a substantial proportion of business establishments and contribute significantly to gross domestic product (GDP), poverty alleviation, and regional development (Afolayan, 2021; World Bank, 2020). In Bayelsa State, SMEs dominate the non-oil private sector, operating largely in trade, services, agro-processing, hospitality, and small-scale manufacturing. Despite their relevance, many SMEs in the state face persistent challenges related to poor management practices, limited strategic capacity, inadequate skills, and inability to achieve set organizational goals.

The attainment of organizational goals, such as profitability, growth, market share expansion, customer satisfaction, and long-term sustainability is fundamental to SME survival and competitiveness. Organizational goals serve as benchmarks that guide business activities and provide direction for decision-making and performance evaluation (Daft, 2021). However, evidence from Nigeria suggests that a high proportion of SMEs fail within their first five years of operation due largely to internal managerial deficiencies rather than external environmental factors alone (SMEDAN, 2022). This has shifted scholarly and policy attention toward the role of the entrepreneur, particularly the competencies possessed by SME owners and managers.

Entrepreneurship competency refers to the underlying characteristics, skills, knowledge, attitudes, and abilities that enable entrepreneurs to effectively perform entrepreneurial roles and functions. According to Man, Lau, and Chan (2002), entrepreneurial competencies encompass opportunity recognition, strategic thinking, relationship building, innovation, risk management, and commitment competencies. These competencies influence how entrepreneurs identify business opportunities, allocate resources, respond to environmental uncertainty, and implement strategies that enhance organizational performance. Contemporary studies emphasize that entrepreneurial success is not solely dependent on access to finance or technology but significantly on the competencies of the entrepreneur who coordinates these resources (Mitchelmore & Rowley, 2019).

International empirical evidence consistently shows a strong relationship between entrepreneurship competency and organizational goal attainment. For instance, Tehseen and Ramayah (2015) found that entrepreneurial competencies significantly influence SME performance indicators such as sales growth, profitability, and competitive advantage. Similarly, Lans, Blok, and Wesselink (2018) argue that entrepreneurs with higher strategic and learning competencies are better positioned to align business operations with organizational objectives in dynamic markets. These findings underscore the importance of competency-based entrepreneurship in achieving sustainable organizational outcomes.

In Bayelsa State specifically, research indicates that competencies such as communication skills, opportunity recognition, and learning orientation have a positive and significant relationship with SME performance and survival (Etekpe & Agbim, 2022). However, many SME operators in the state still rely on intuition and informal management practices, which often limits their ability to systematically pursue and attain organizational goals.

### **Statement of the Problem**

Small and Medium Enterprises (SMEs) play a critical role in Nigeria's economic development through employment generation, income creation, poverty reduction, and stimulation of local innovation. In Bayelsa State, SMEs constitute a significant proportion of business establishments across various Local Government Areas (LGAs), contributing to grassroots economic activities and community development. Despite their importance, many SMEs in the state struggle to attain their organizational goals such as profitability, growth, business sustainability, market expansion, and long-term survival (SMEDAN, 2023).

The persistence of low performance, business stagnation, and failure among SMEs in the state raises critical questions about the role of entrepreneurship competency in enhancing organizational effectiveness. Without empirical evidence on how specific entrepreneurial competencies affect the attainment of organizational goals within selected LGAs of Bayelsa State, policy makers, SME support agencies, and entrepreneurs themselves may lack the necessary insights to design effective capacity-building and intervention programs. This study therefore seeks to address this gap by examining the relationship between entrepreneurship competency and the attainment of organizational goals of SMEs in selected LGAs in Bayelsa State.

## **Objectives of the Study**

1. examine the extent to which opportunity recognition competency influences profitability of the SMEs in selected LGAs of Bayelsa State;
2. determine the influence of organizing competency on SMEs' market share in selected LGA in Bayelsa State.

## **Research Questions**

Based on the above, the study seek to answer the following questions:

1. To what extent does opportunity recognition competency influence profitability of the SMEs in selected Local Government Areas of Bayelsa State?
2. What is the effect of organizing competency on the attainment of market share of SMEs of selected LGA in Bayelsa State?

## **Research Hypotheses**

The hypotheses below are stated in null form (for statistical testing) and align directly with the research questions and objectives:

(H01): There is no significant relationship between opportunity recognition competency and profitability of SMEs in selected Local Government Areas of Bayelsa State.

(H02): There is no significant effect of organizing competencies and market share of SMEs in selected Local Government Areas of Bayelsa State.

## **2. Literature Review**

### **Concept of Entrepreneurial Competency**

Entrepreneurship competency refers to the bundle of knowledge, skills, attitudes, and personal attributes that enable entrepreneurs to identify opportunities, mobilize resources, and achieve organizational goals effectively. The following are some of the dimensions. Man, Lau & Chan (2002): Entrepreneurial competencies are the total ability of an entrepreneur to perform job roles successfully in business. Opportunity Recognition Competency: This is the entrepreneur's ability to identify, evaluate, and exploit viable business opportunities in the environment. It involves market sensing, creativity, and innovation. Here, the entrepreneur is able to recognize certain vital keys that would enhance his business, which includes; Environmental scanning, Customer need identification, Innovation and idea generation. Scholars argue that opportunity recognition is central to entrepreneurial success because it precedes venture creation and growth (Shane & Venkataraman, 2000; Urban & Wood, 2017). Strategic Competency: Strategic competency involves the ability to set goals, formulate strategies, and align resources to achieve long-term organizational objectives. These involves; vision formulation, Strategic, competitive positioning. Entrepreneurs with strong strategic competency are more likely to sustain competitive advantage and organizational performance; (Tehseen & Ramayah, 2015). Strategic competency significantly influences planning, decision-making, and performance outcomes in SMEs (Ramadhan et al., 2024).

### **Profitability**

Profitability is the primary goal of all business ventures, and without profitability the business will not survive in the long run (Hofstrad &Johanns, n.d.). It is a measurement of efficiency – and ultimately a business success. Horton (2021) defined profitability as a business's ability

to produce a return on an investment based on its resources in comparison with an alternative investment. While Kadian-Baumeyer(2021) saw Profitability as the revenue left over after all expenses and taxes have been paid.

## **Market Share**

Organizations uses market share to measure marketing performance. Market share could be seen as the percentage of sales of a product in units, Naira, or some other significant measure made by a company relative to all sales of that same product, normally for a particular geographic unit and always for a specific time period, e.g., November 2020 (Louis, 2005). It is the ability of business performance management in assessing the extent to which consumers patronize a given product in the market environment (Diller, et al., 2006).

## **Empirical Review**

Several empirical studies in Nigeria have examined how entrepreneurship competency influences SMEs' ability to attain organizational goals such as profitability, growth, market expansion, and sustainability.

According to Poi and Wariboko (2021) examined entrepreneurship competencies and competitive advantage among SMEs in Bayelsa State. Findings showed that strategic planning competency and networking competency had a strong positive effect on SMEs' competitive positioning, which directly enhanced organizational goal attainment. The study emphasized that competency-driven decision-making enables SMEs to adapt to environmental uncertainty.

Similarly, Azuonwu, Baridam, and Emenike (2022) investigated entrepreneurial competencies (managerial, innovative, and opportunity-recognition competencies) and SME performance in the Niger Delta region. Using a survey research design and regression analysis, the study revealed that managerial and innovative competencies significantly influenced goal attainment, especially sales growth and customer retention. The study concluded that SMEs that invest in developing entrepreneurial skills are more likely to achieve their organizational objectives..

Furthermore, Adebayo and Adekunle (2019) studied entrepreneurship competencies and SME performance in South-West Nigeria. Their findings revealed that financial management competence and opportunity identification competence significantly predicted profitability and sustainability of SMEs. The study reinforced the relevance of competency development for organizational goal achievement in developing economies.

Likewise, In Kenya, Mwangi and Namusonge (2020) investigated the effect of entrepreneurial competencies on SME growth. Their findings showed that risk-taking competency and innovation competency positively affected sales growth and business expansion, supporting the argument that entrepreneurial competencies are instrumental in achieving organizational targets.

## **Theoretical review**

### **Resource-Based View (RBV)**

The Resource-Based View (RBV) posits that firms achieve sustainable competitive advantage and superior performance by effectively utilizing valuable, rare, inimitable, and non-substitutable resources and capabilities within the organization (Barney, 1991). This theory emphasizes that internal resources, including entrepreneurial competencies (skills, knowledge, strategic insight) are critical for goal attainment and performance outcomes in SMEs.

### 3. Methodology

This research design adopted descriptive research method which involves qualitative approach. The population of the study consisted of owners and managers of registered Small and Medium Enterprises (SMEs) operating within the selected Local Government Areas of Bayelsa State. The study employed a multi-stage sampling technique, which involved purposive sampling to select LGAs with a high concentration of SMEs which are Yenagoa, Sagbama and Ogbia LGA, while the random sampling to select 40 SMEs for each LGA within the chosen LGAs, which brings the total 120.

Sources of Data: The study utilized primary data. Primary data were obtained directly from SME owners and managers through the administration of structured questionnaires.

Instrument for Data Collection: The research instrument used for data collection was a structured questionnaire.

Validity of the Instrument: The validity of the instrument was ensured through content and face validity. Copies of the questionnaire were given to experts in entrepreneurship, business administration, and research methodology to examine the relevance, clarity, and adequacy of the items. Their suggestions and corrections were incorporated before the final administration.

Reliability of the Instrument: The reliability of the instrument was tested using the Cronbach's Alpha method after a pilot study was conducted. A reliability coefficient of 0.70 and above was considered acceptable, indicating that the instrument was internally consistent and reliable for the study.

Method of Data Analysis: Descriptive statistics such as frequencies, percentages, means, and standard deviations were used to analyze the research questions, while Pearson Product Moment Correlation, was used to test the hypotheses at a 0.05 level of significance.

### 4. Data Analysis

#### Demographic Analysis

**Table 1: Showing statistics**

	Gender	Qualification	Occupation	Marital status
N Valid	120	120	120	120
Missing	0	0	0	0
Mean	1.23	2.04	2.98	1.41
Std. Deviation	.425	.956	1.065	.587

Source field survey 2025

**Table 2 Showing frequency of gender**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Male	92	76.7	76.7	76.7
Female	28	23.3	23.3	100.0
Total	120	100.0	100.0	

Source Field survey 2025

Figure 1 showing bar chart of opportunity recognition competencies

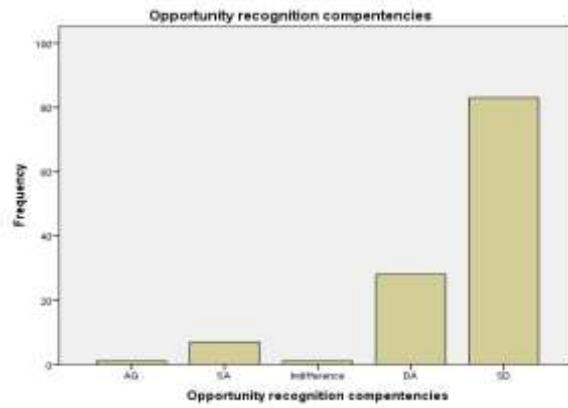


Figure 2; showing pie chart of opportunity recognition competencies

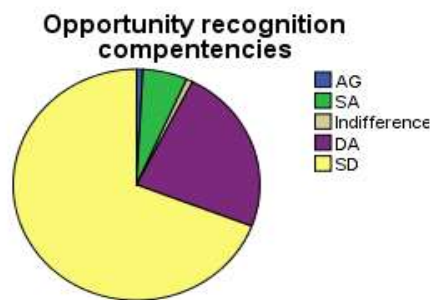


Figure 4; showing bar chart of organizing competencies.

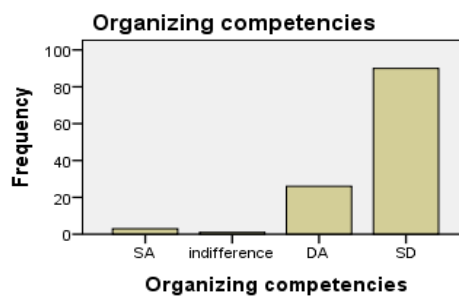
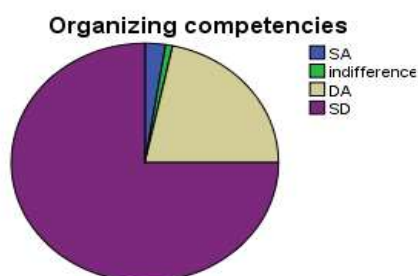


Figure 2: showing pie chart of organizing competencies'



H01: There is no significant relationship between opportunity recognition competencies and profitability.

**Tables 3: showing correlation**

	Opportunity recognition competencies	Profitability
Opportunity recognition competencies	1	.971**
	Pearson Correlation	.000
	Sig. (2-tailed)	120
	N	120
Profitability	.971**	1
	Pearson Correlation	.000
	Sig. (2-tailed)	120
	N	120

\*\* . Correlation is significant at the 0.01 level (2-tailed).

The correlation table established the relationship between opportunities recognition competencies and profitability. It shows that the correlation coefficient (r) is .971\*\* This reveals that there is a strong relationship between opportunities recognition competencies and profitability in selected SME in Bayelsa State, with the implication sign value of (r) is positive while the p value is  $0.000 < 0.05$ . Therefore we reject the null hypothesis and accept the alternative hypothesis, which implies there is a significant relationship between opportunity recognition competencies and profitability in selected SME in Bayelsa State.

H02: There is no significant relationship between organizing and leading competencies and market share in selected SME in Bayelsa State.

**Table 4: showing correlation**

	Organizing and leading competency	Market Share
Organizing and leading competency.	1	.987**
	Pearson Correlation	.000
	Sig. (2-tailed)	120
	N	120
Market Share	.987**	1
	Pearson Correlation	.000
	Sig. (2-tailed)	120
	N	120

\*\* . Correlation is significant at the 0.01 level (2-tailed).

The correlation table revealed the relationship between organizing and leading competencies and market share in selected SMEs in Bayelsa State.. It shows that the correlation coefficient (r) is .987\*\* This established that there is a strong relationship between organizing and leading competencies and market share in selected SME in Bayelsa State, with the implication sign value of (r) is positive while the p value is  $0.000 < 0.05$ . Therefore we reject the null

hypothesis and accept the alternative hypothesis, which implies there is a significant relationship between organizing and leading competencies and market share opportunity in selected SME in Bayelsa State.

## **5. Discussion of findings**

This section discussed the findings obtained in the study concerning the hypothesized relationship.

One of the objectives of this study was to determine the relationship between opportunity recognition competencies and profitability of SMEs in selected LGA in Bayelsa State. To what extent opportunity recognition competencies relates to profitability. Opportunity recognition competencies was discovered to have a significant positive relationship with profitability. This finding was generated from the outcome of the statistical test of hypotheses Ho1. The test of Ho1 revealed that opportunity recognition competencies attracts a significant positive correlation coefficient ( $r = 0.971$ ,  $p\text{-value} < 0.05$ ). That is, the more business opportunities recognized the more they make profit.

One of the objectives of this study was to determine the relationship between innovative competencies and market share of SMEs selected LGA in Bayelsa State. To what extent innovative competencies relates to market share, innovative competencies was discovered to have a significant positive relationship with market share of SMEs in selected LGA in Bayelsa State. This finding was generated from the outcome of the statistical test of hypotheses Ho2. The test of Ho2 revealed that innovative competencies gains a significant positive correlation coefficient ( $r = 0.987$ ,  $p\text{-value} < 0.05$ ).

## **6. Conclusion**

Many reviewed literature collectively established the vital role entrepreneurship play in achieving broader economic goals. We can see from the results that there is strong relationship between entrepreneurship competency and attainment of organizational goal of selected SME in Bayelsa State.

## **7. Recommendation**

The recommendations after the study are that:

- 1 the organization should adopt continuous entrepreneurial training,
- 2 the organization should ensure periodic capacity development programs.
- 3 management support policies aimed at strengthening entrepreneurial competencies among SME operators.

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# Transportation and Management in Nigeria: Changes, Reforms, and Sustainable Development Pathways

I.U ANYANWU <sup>1</sup> & ALLWELL ANABA <sup>2</sup>

Department of Urban and Regional Planning, Ogbonnaya Onu  
Polytechnic Aba

## ABSTRACT

*Over the years, transportation systems are vital for economic growth, social mobility, and sustainable development. In Nigeria—Africa's most populous nation—transportation has undergone significant changes and reforms to address urbanization, economic diversification, infrastructure deficits, and environmental pressures. This paper examines Nigeria's transportation evolution, evaluates policy reforms, identifies prevailing challenges, and proposes sustainable development pathways to improve mobility, reduce environmental impacts, and promote inclusive socio-economic growth.*

## INTRODUCTION

Transportation constitutes an essential backbone for national development. In Nigeria, a diverse array of transport modes—including road, rail, aviation, and maritime—serve both domestic and international trade, connect rural and urban populations, and support key sectors such as agriculture, manufacturing, and services. However, decades of demographic growth, rapid urbanization, and underinvestment have strained Nigeria's transport infrastructure and management capacity. Repeated policy shifts, institutional reforms, and public-private partnerships demonstrate concerted efforts to modernize the sector. This paper analyzes Nigeria's transportation landscape, tracks reforms over time, and identifies sustainable pathways that align with economic priorities and environmental imperatives.

## HISTORICAL OVERVIEW OF TRANSPORTATION IN NIGERIA

### Colonial Era to Independence

Nigeria's transportation infrastructure dates to colonial times, primarily designed to support extractive economic activities. Rail lines from Lagos to Kano and port facilities in Lagos and Port Harcourt facilitated trade exports.

### Post-Independence Expansion

After 1960, Nigeria expanded road networks rapidly to connect regional capitals and rural hinterlands. Road transport grew dominant due to flexibility and cost advantages compared to neglected railways.

### Structural Adjustment and Liberalization (1980s–1990s)

Economic reforms reduced government control, encouraging private sector participation in transport services. However, underfunded public infrastructure and weak institutional oversight led to congestion, inefficiencies, and safety challenges.

## **Sectoral Analysis of Transportation Modes**

### **1. Road Transportation**

Roads account for over 90% of passenger and freight movement in Nigeria. Major federal highways link states and economic zones. Despite extensive network coverage, asphalt conditions vary widely due to insufficient maintenance funding and climatic stressors.

#### **CHALLENGES**

- Poor road maintenance and potholes
- Traffic congestion in megacities (e.g., Lagos, Abuja, Port Harcourt)
- High rates of road traffic accidents

### **2. Railways**

The rail sector witnessed decades of neglect until recent revitalization efforts. Modern gauge rail projects aim to restore inter-city connectivity.

#### **Modern Investments**

- Lagos–Kano Standard Gauge Railway
- Abuja–Kaduna rail line
- Port upgrades to facilitate container flows

#### **Aviation**

Aviation supports global connectivity and domestic travel. Nigeria hosts several international airports with ongoing modernization initiatives to meet safety and capacity demands.

#### **Maritime and Inland Waterways**

Ports in Lagos, Onne, and Warri are critical trade nodes. Inland waterways offer potential to decongest roads and reduce logistics costs.

## **TRANSPORT MANAGEMENT AND POLICY REFORMS**

### **Institutional Framework**

Nigeria's transport policy environment is managed by multiple agencies—each responsible for planning, regulation, and enforcement across modes. Key institutions include:

- Federal Ministry of Works and Housing
- Federal Ministry of Transportation
- Nigerian Civil Aviation Authority (NCAA)
- Nigerian Maritime Administration and Safety Agency (NIMASA)

## **Reform Strategies**

### **Public-Private Partnerships (PPPs)**

The government has promoted PPPs to attract investment in roads, railways, and terminals, aiming to reduce fiscal burdens and improve efficiency.

### **Regulatory Revisions**

Revised traffic laws and transport safety codes aim to improve standards, professionalize drivers, and enforce compliance.

### **Urban Transit Initiatives**

Bus Rapid Transit (BRT) systems in Lagos and Abuja demonstrate efforts to improve urban mobility and reduce private vehicle dependence.

## **CHALLENGES AND BARRIERS**

Despite reforms, Nigeria faces several impediments:

**Institutional Fragmentation:** Overlapping mandates and weak policy coordination often slow project implementation and enforcement.

**Financing Gaps:** Limited public funds and challenges in mobilizing private financing constrain infrastructure expansion and upgrading.

**Environmental and Safety Concerns:** Unregulated vehicle emissions contribute to air pollution. High accident rates reflect gaps in enforcement, driver training, and road design.

**Informal Transport Sector:** Informal operators dominate urban transit, posing challenges for regulation, safety, and integration with formal systems.

**Sustainable Development Pathways:** Achieving sustainable transportation in Nigeria requires multi-dimensional strategies:

**Strengthened Institutional Governance:** Enhance inter-agency coordination

**Implement data-driven planning:** Promote transparency in procurement and project monitoring.

**Investment in Integrated Public Transit:** Develop mass transit systems (rail, BRT, light rail) that reduce private car use, lower congestion, and expand access for underserved populations.

**Financing Mechanisms:** Mobilize blended financing—combining government funds, private capital, and development finance institutions—to support large infrastructure projects and maintenance funds.

## **SAFETY AND ENVIRONMENTAL STANDARDS**

- i. Enforce vehicle emission controls.
- ii. Upgrade road signage and design.
- iii. Expand road safety education and professionalize drivers.

## **Digitalization and Smart Mobility**

Use digital platforms for traffic management, ticketing, and logistics tracking to improve efficiency and reduce downtime.

## **Strengthening the Informal Sector**

Incorporate informal transit operators into formal systems through training, incentives, and regulation to enhance safety and service quality.

## **Case Studies**

### **Lagos BRT System**

The Lagos BRT provides structured routes with dedicated lanes, reducing transit times and emissions compared to informal shared taxis. Lessons underscore the need for supporting infrastructure and enforcement of exclusive lanes.

### **Abuja–Kaduna Rail Line**

The Abuja–Kaduna route revived rail passenger services, demonstrating demand for reliable inter-city travel. Safety and scheduling improvements have boosted ridership.

## **CONCLUSION**

Nigeria's transportation sector stands at a critical juncture—balancing legacy infrastructure challenges with ambitious reform agendas. Without sustained investment, coordinated management, and sustainable innovation, transportation cannot fully drive national development goals. However, progressive policies, integrated transit systems, and cross-sector partnerships can unlock efficiencies, enhance mobility, and support equitable economic growth across regions.

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# Digital Transformation and Sustainable Development of Beverage Firms in Port Harcourt

Dr. Lucky Tema<sup>1</sup>, & Dr. Willy Nelson Ogoja<sup>2</sup>

<sup>1</sup> Department of Business Administration, Federal Polytechnic Ekowe Bayelsa State

<sup>2</sup> Department of Accounting, Federal Polytechnic Ekowe, Bayelsa state

Email: [tokstema7@gmail.com](mailto:tokstema7@gmail.com) <sup>1</sup>; [nelsonwilly79@gmail.com](mailto:nelsonwilly79@gmail.com) <sup>2</sup>

## ABSTRACT

*This study investigated the connection between digital transformation and sustainable development within the context of beverage firms in Port Harcourt, Nigeria. The objective is to determine the relationship between digital transformation and sustainable Development of Food and Beverage Firms in Port Harcourt. As global business environments evolve, the adoption of digital technologies has become essential for enhancing operational efficiency, innovation capacity, and long-term sustainability. This paper applied a descriptive statistics and quantitative approach, while the population comprised of 23 registered food and beverages firms in Port Harcourt, Rivers State, Nigeria. The combination of random sampling and purposive sampling technique were adopted. The food and beverages firms were selected using purposive sampling technique, while random sampling was used to select 12 food and beverages firms in Port Harcourt. The research explores how digital tools, such as automation, data analytics, and integrated management systems are being leveraged to address the economic, environmental, and social dimensions of sustainability in the beverage industry. This paper adopted quantitative correlation approach of analysis. The findings reveal that digital transformation significantly contributes to improved resource utilization, reduced production waste, streamlined supply chain management, and enhanced customer engagement. Furthermore, digitalization supports corporate social responsibility initiatives and workforce development, thereby reinforcing the social aspect of sustainability. The paper concludes that while digital transformation is not a panacea, its strategic implementation can serve as catalyst for sustainable development in Nigeria's beverage sector. It therefore recommends targeted investments in digital infrastructure, capacity building and policy frameworks that incentivize digital innovation aligned with sustainability goals.*

KEYWORDS: Digital transformation, sustainable development, Digital technology, resource efficiency, innovation.

## Introduction

In recent years, the intersection of digital transformation and sustainable development has garnered significant attention from both scholars and practitioners across various industries. Digital transformation refers to the integration of digital technologies into all areas of a business, fundamentally changing how organizations operate and deliver value to customers (Köhler et al., 2021). On the other hand, sustainable development emphasizes meeting the needs of the present without compromising the ability of future generations to meet their own needs, focusing on economic growth, social inclusion, and environmental protection (United Nations, 2015).

The beverage industry, characterized by its complex supply chains and substantial environmental footprints, is particularly relevant to studies exploring these themes. In Port Harcourt, a bustling city in Nigeria's Niger Delta region known for its vibrant industrial landscape, beverage firms face unique challenges and opportunities in implementing digital transformation strategies aimed at enhancing their sustainability initiatives. As the demand for environmentally friendly and socially responsible products continues to rise, firms are increasingly turning to digital technologies to optimize processes, improve transparency, and engage consumers in more meaningful ways (Bharadwaj et al., 2013).

The digital revolution has profoundly transformed the way businesses operate, driving them to adapt to new technologies that not only enhance efficiency but also promote sustainability. Digital transformation encompasses the adoption of digital tools and innovations that fundamentally alter business processes, customer interactions, and value creation strategies (Westerman et al., 2014). As firms increasingly recognize the importance of sustainable development, they are leveraging digital technologies to align their operations with environmental, social, and governance (ESG) criteria. This trend is particularly notable in the beverage industry, where traditional practices are challenged by consumer demands for transparency, ethical sourcing, and reduced environmental impact (Hahn et al., 2015).

In Port Harcourt, Nigeria, the beverage sector serves as a critical pillar of the local economy, providing employment and contributing to economic growth. However, the region is also grappling with numerous sustainability challenges, including waste management, water scarcity, and pollution (Adelaja & Daramola, 2019). Digital transformation presents an opportunity for beverage firms in Port Harcourt to address these challenges while fostering sustainable practices. By integrating technologies such as data analytics, supply chain management software, and mobile applications, firms can enhance operational efficiency and transparency, reduce waste, and promote social responsibility.

Digital transformation and sustainable development are interlinked through various mechanisms. For instance, data analytics can facilitate better decision-making by providing real-time insights into resource consumption and waste generation, enabling firms to optimize their operations (Tundy & Schuster, 2020). Additionally, technologies like the Internet of Things (IoT) can improve monitoring and traceability within supply chains, helping firms adhere to environmentally friendly practices (Bai et al., 2022). Furthermore, customer engagement platforms help businesses raise awareness about their sustainability efforts, fostering consumer loyalty and brand reputation (Nidumolu et al., 2009).

The global business landscape is undergoing rapid transformation due to digital innovations, significantly impacting operational architectures and sustainability practices across industries. The concept of digital transformation encompasses various technological advancements, such as artificial intelligence (AI), big data analytics, cloud computing, and the Internet of Things (IoT), which enable organizations to improve their processes, products, and services (Fitzgerald et al., 2014). This transformation is not only about technology adoption but also involves cultural and organizational changes that foster agile thinking, improved customer engagement, and enhanced value delivery.

At the same time, the imperative for sustainable development has intensified, driven by growing environmental concerns and heightened consumer awareness regarding corporate responsibility (Elkington, 1997). In particular, the beverage industry faces scrutiny due to its water-intensive manufacturing processes, packaging waste, and environmental impact (Patterson, 2016). In Port Harcourt, a city with rich natural resources and a robust beverage manufacturing sector, firms are increasingly recognizing the dual necessity of embracing

digital transformation to enhance operational efficiency while aligning with sustainable practices (Ukoha et al., 2022).

Digital transformation can play a pivotal role in addressing sustainability challenges within the beverage industry. One of the major areas of impact is the optimization of resource management. For instance, data analytics can enable companies to monitor their water and energy usage more effectively, facilitating better resource allocation and minimizing waste (Rai et al., 2019). Moreover, machine learning algorithms can predict demand patterns, allowing firms to adjust production levels accordingly, reducing overproduction and unnecessary resource consumption (Wang, Gunasekaran, & Ngai, 2016).

Furthermore, advancements in supply chain transparency can lead to better sustainability outcomes. Technologies such as block chain enable firms to track product origins, ensuring ethical sourcing practices and improving consumer trust (Kamble et al., 2021). In the context of Port Harcourt's beverage firms, such technologies can provide assurance regarding the sustainability of raw materials, enhancing compliance with local and international regulations while meeting consumer demands for transparency.

Customer engagement is another critical area where digital transformation influences sustainability. By utilizing digital marketing tools and social media platforms, beverage firms can effectively communicate their sustainability initiatives to consumers, fostering a sense of community and shared values (Mishra et al., 2020). Engaging customers through ramification or loyalty programs centered on sustainability can drive behavioral changes and promote conscious consumption patterns among consumers.

Despite the potential benefits, beverage firms in Port Harcourt face several challenges in implementing digital transformation initiatives geared towards sustainability. A significant barrier is often the lack of adequate infrastructure and digital literacy among employees, which can hinder the effective adoption of new technologies (Ogunyemi et al., 2020). Moreover, financial constraints may limit the ability of smaller firms to invest in advanced digital solutions, thereby exacerbating inequalities within the industry. Additionally, resistance to change within organizations can pose a significant obstacle to successful digital transformation. Employees may fear job displacement due to automation, leading to pushback against technological investments (Bendoly et al., 2020). To mitigate these issues, firms must prioritize training and reskilling employees, fostering a culture that embraces innovation and sustainability at all levels.

### **Statement of the Problem**

The intersection of digital transformation and sustainable development presents a critical area of inquiry for businesses navigating the contemporary economic landscape. In the beverage industry, where operational practices significantly impact environmental and social dimensions, the effective integration of digital technologies is imperative for fostering sustainable development. However, in Port Harcourt, Nigeria, a region characterized by its rich natural resources and burgeoning beverage sector, several challenges inhibit the full realization of this potential. **Resource Inefficiency:** Beverage firms often operate with outdated systems and practices that lead to excessive resource consumption, including water, energy, and raw materials. The lack of real-time data analytics and monitoring technologies hampers their ability to optimize production processes and manage resources sustainably. **Environmental Impact:** The beverage industry is notorious for its substantial environmental footprint, including high water usage, waste generation from packaging, and significant carbon emissions. Many firms in Port Harcourt struggle to implement effective sustainability initiatives due to limited access to advanced digital tools that can track and mitigate these impacts.

**Limited Adoption of Digital Technologies:** While digital transformation has proven beneficial for firms globally, the adoption rate among beverage companies in Port Harcourt is inconsistent. Factors such as inadequate infrastructure, lack of digital literacy among employees, and financial constraints impede the successful implementation of technological solutions that could enhance sustainability practices.

**Consumer Awareness and Expectations:** Increasingly, consumers are demanding transparency and accountability from brands regarding their sustainability efforts. However, many local beverage firms lack the tools to effectively communicate their sustainable practices or to engage with consumers in ways that align with emerging digital trends.

**Resistance to Change:** Organizational culture within many beverage firms may resist the shifts required for successful digital transformation. Employees may be apprehensive about technological changes, fearing job loss or disruption. This resistance can prevent firms from realizing the full benefits of integrating sustainability into their digital strategies.

**Knowledge Gaps:** There is a relatively low level of understanding regarding the synergistic relationship between digital transformation and sustainable development specifically in the context of the beverage industry in Port Harcourt. A lack of empirical research focusing on these dynamics hinders firms from making informed decisions and developing effective strategies.

This study seeks to address these issues by exploring how digital transformation can enable beverage firms in Port Harcourt to enhance sustainability efforts. By investigating the barriers to adoption and identifying best practices, this research aims to provide actionable insights that could pave the way for more sustainable and competitive operations in the local beverage industry. Through this investigation, the study will contribute to a deeper understanding of the unique challenges faced by firms in Port Harcourt and offer solutions to leverage digital transformation for sustainable development.

### **Objectives to the Study**

The objectives of the study on the effect of digital transformation and sustainable development in the context of beverage firms in Port Harcourt are as follows:

1. To determine the relationship between Digital Transformation and Sustainability development of food and beverages in Port Harcourt.
2. To examine the sustainability practices currently implemented by food and beverage firms in Port Harcourt.

Therefore, the study is concerned in addressing the following questions.

1. How does digital transformation influence sustainability development in beverage firms in Port Harcourt?
2. What sustainability practices are being implemented by beverage firms in Port Harcourt, and how effective are these practices

### **Hypothesis**

**H01:** There is no relationship between digital transformation and Sustainability development in beverages firms in Harcourt.

**H02:** There is no significant relationship between sustainability practices and sustainable development in food and beverages firms in Port Harcourt, Rivers State.

## **Literature Review**

Digital transformation refers to the strategic integration of technology into all areas of an organization or society, fundamentally changing how value is created, delivered and sustained. It goes beyond mere digitization or automation, it involves a holistic rethinking processes, business models, organizational culture and stake holders engagement through digital technologies (Vial 2019).

### **Environmental Sustainability and Digital Transformation**

Environmental sustainability in food and beverage firms revolves around reducing environmental footprints through responsible sourcing, energy efficiency, waste management, and emissions reduction. In Port Harcourt, a city grappling with industrial pollution and environmental degradation, digital transformation has the potential to enhance environmental stewardship in food and beverage firms. Digital tools like IoT sensors and blockchain can track resource usage, monitor emissions, and optimize supply chains to reduce carbon footprints. For example, real-time energy management systems can help firms monitor and control energy use, reducing environmental harm (Awan et al., 2022). Additionally, automation and AI-powered quality controls can minimize waste during production. According to UNDP (2021), digital solutions in developing countries have shown great promise in environmental monitoring, supporting sustainability in manufacturing processes. Thus, in Port Harcourt, adopting smart manufacturing technologies and digitized logistics systems can contribute to cleaner production and a more sustainable food system.

### **Social Equity in the Context of Digital Transformation**

Social equity refers to the fair treatment, opportunities, and advancement for all people. In food and beverage firms, this implies equitable labor practices, inclusivity, gender equality, and community development. Digital transformation can promote social equity by; Enhancing transparency in labor practices, providing platforms for employee training and upskilling and supporting inclusive hiring through digital HR platforms. In Port Harcourt, digital literacy gaps and socio-economic inequalities exist, so firms need to ensure their digital strategies include capacity-building for low-skilled workers. For example, equipping employees with digital skills through internal e-learning platforms can reduce inequality and improve social outcomes (Osabuohien et al., 2020). Moreover, community engagement platforms and digital feedback systems can allow firms to respond to local needs and strengthen community relationships, aligning with the SDGs—especially Goals 8 (Decent Work) and 10 (Reduced Inequality).

### **Resource Efficiency through Digital Technologies**

Resource efficiency involves maximizing output with minimal resource input—crucial in Port Harcourt where resource constraints and high production costs are prevalent. Digital transformation enables; Predictive analytics to reduce inventory and spoilage, smart warehousing and logistics systems to minimize fuel and storage costs and AI algorithms for optimal resource allocation. Food and beverage companies like Nigerian Bottling Company (a Coca-Cola franchise) have reported success using digital tools to monitor water usage and energy consumption in their production processes (Nigerian Bottling Company, 2022). Such innovations reduce operational costs while promoting sustainability. Furthermore, ISO 14001 environmental management systems, supported by digital tracking, allow firms to monitor compliance and continuously improve resource efficiency (Chofreh et al., 2019).

## **Economic Viability and Competitiveness**

Economic viability refers to the ability of firms to sustain operations profitably over the long term. Digital transformation enhances competitiveness through improved productivity, cost savings, market responsiveness, and product innovation. For food and beverages firms in Port Harcourt; E-commerce platforms allow for wider market reach, likewise, data analytics improves customer targeting and forecasting, finally, digitized supply chains reduce costs and enhance responsiveness. According to Adegbile et al. (2021), digital innovation in Nigerian SMEs has led to increased market access, revenue growth, and operational efficiency. Thus, digitalization can significantly boost economic viability, particularly in a dynamic consumer market like Port Harcourt's. Furthermore, digital tools help companies adapt to shocks (like COVID-19), ensuring business continuity, which is critical for economic resilience in volatile markets.

## **Innovation for Sustainability**

Innovation is a catalyst for sustainable development. In the context of food and beverage firms, innovation involves developing new products, processes, or business models that reduce environmental and social harm while creating economic value. Digital transformation fosters such innovation by; Enabling digital product development (e.g., plant-based foods using AI-based R&D), Encouraging collaborative platforms for stakeholder-driven innovation and supporting real-time data analytics to identify new sustainable market opportunities. In Port Harcourt, where urbanization and population growth drive demand for processed foods, firms can leverage innovation to introduce healthier, environmentally-friendly products using green technologies (Okon & Etim, 2022).

## **Theoretical review**

In relation to the paper on Digital Transformation and Sustainable Development, these theories were adopted:

### **Innovation Diffusion Theory**

The Innovation Diffusion Theory (IDT), proposed by Everett M. Rogers in his seminal work "Diffusion of Innovations" (1962), is one of the most influential frameworks for understanding how, why, and at what rate new ideas, technologies, or practices spread within a social system over time. The theory blends elements from sociology, communication, marketing, and organizational studies to explain the process by which innovation is communicated and adopted.

According to Rogers (2003), the diffusion of innovation involves four key elements.

1. **Innovation:** An innovation is "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 2003, p. 12). Importantly, it is the perception of newness, not the actual date of invention, that defines an innovation in this context.
2. **Communication Channels:** This refers to the means by which information about the innovation is transmitted. Communication can be interpersonal (e.g., word of mouth) or mass media (e.g., television, social media). The effectiveness of these channels varies depending on the stage of adoption.
3. **Time:** Time is involved in:
  - The innovation-decision process (how long it takes to adopt),

- The innovativeness of an individual or group, and
- The rate of adoption within a social system.

4. **Social System:** The set of interrelated units (individuals, organizations, or institutions) engaged in joint problem-solving to accomplish a common goal. Norms, roles, and structure within the system influence the diffusion process.

Confirmation: Seeking reinforcement for the decision and possibly reversing it if exposed to conflicting messages.

### **Value Creation Theory**

This theory was proposed by Prahalad, C. K., & Ramaswamy, V. (2004). Which states that businesses need to create value not just for shareholders but for all stakeholders. Digital transformation can enhance value creation by improving efficiency, customer satisfaction, and sustainability practices. Value Creation Theory explains how organizations, individuals, or systems generate value for stakeholders, whether customers, shareholders, employees, or society at large. This theory is foundational in fields such as economics, business strategy, innovation, and entrepreneurship. It emphasizes not only generating wealth or profit but also delivering meaningful benefits, outcomes, or improvements in a given context. The central premise of value creation is that organizations exist to create value, and their sustainability and success depend on their ability to continuously do so in an efficient, effective, and innovative way.

#### Theoretical Foundations

Value creation has roots in several classical and modern economic theories such as:

##### Classical Economics (Adam Smith, 1776)

Adam Smith in *The Wealth of Nations* emphasized labor as the source of value. He argued that value arises from productive labor and the specialization of tasks.

##### Marxian Theory of Value (Karl Marx, 1867)

Karl Marx advanced the labor theory of value, stating that value is created through labor and that capitalist profit is derived from the exploitation of labor (Marx, 1867).

##### Neoclassical Economics

Later economists emphasized utility and marginalism, suggesting that value is created based on individual preferences and the marginal utility derived by consumers

##### Modern Perspectives on Value Creation

Modern theories extend beyond just cost or utility to include innovation, stakeholder benefits, and ecosystem collaboration.

##### Porter's Value Chain

Michael Porter introduced the Value Chain Model, which illustrates how internal activities in a firm, such as operations, marketing, and after-sales services add value to a product or service. Porter (1985) defines value as what buyers are willing to pay, and a firm is profitable when the value it creates exceeds the cost of performing value activities

## Empirical review

Digital transformation has become a critical driver of innovation, efficiency, and sustainability across sectors, including the food and beverages (F&B) industry. Several empirical studies have investigated the impact of digital technologies on firm performance, sustainability practices, and operational efficiency. This section reviews relevant empirical literature to contextualize how digital transformation influences sustainable development, with specific attention to the food and beverages sector in Port Harcourt, Nigeria.

A study by Okonkwo and Nwachukwu (2021) examined the impact of digital tools on sustainability practices among SMEs in Rivers State, including food processing firms. Using a structured questionnaire and regression analysis on data from 120 respondents, the study found that the adoption of digital platforms such as e-commerce, inventory automation, and mobile apps significantly reduced waste and improved energy efficiency. The authors concluded that digital adoption positively influenced environmental sustainability and customer engagement but noted challenges in infrastructure and staff training.

Similarly, Effiong and Udo (2020) explored digital innovation and operational sustainability in food firms in the Niger Delta, including Port Harcourt. Their mixed-method approach—combining surveys and in-depth interviews, revealed that firms leveraging data analytics, digital supply chain systems, and automated quality control recorded lower carbon footprints and improved resource management. However, the study identified a gap in digital literacy among employees, which hindered full implementation.

In another relevant study, Ijeoma and Brown (2022) conducted an empirical assessment of the relationship between digital transformation and business sustainability in 15 food and beverage companies in Port Harcourt metropolis. Using correlation and multiple regression models, their findings revealed a strong, positive association between the use of Enterprise Resource Planning (ERP) systems and long-term economic sustainability (measured through return on investment and cost savings). Their study emphasized that digitalization enables transparency and accountability in operations, which is critical for achieving Sustainable Development Goals (SDGs) in the sector.

Further, Akinola et al. (2019) studied the role of digital marketing in the sustainable growth of agro-food businesses in Southern Nigeria. They used survey data from 200 respondents across several urban centers, including Port Harcourt. The results showed that firms using digital marketing tools like social media advertising and online feedback mechanisms had better market reach and consumer loyalty—two key indicators of social and economic sustainability. However, they also noted that inconsistent power supply and limited broadband access constrained digital effectiveness.

Chinweuba and Ogbonda (2022) conducted a quantitative study on 50 food processing firms in Rivers State using structured questionnaires and regression analysis. Their findings revealed that firms adopting sensor-based monitoring systems and digital tracking for inventory and logistics significantly reduced raw material waste and energy consumption. The study affirmed that automation helps minimize environmental footprints by controlling inputs more precisely.

Similarly, Ekanem and Osei (2021) found that digital supply chain systems—particularly cloud-based inventory control and GPS-enabled distribution led to more efficient logistics operations among beverage producers in the South-South region, including Port Harcourt. Their data, collected from 160 respondents, showed a 23% reduction in transport-related emissions in firms that had implemented digital tracking tools. This aligns with global research linking smart technologies to eco-efficiency.

However, Worlu and Adiele (2020) cautioned that while digital tools offer environmental benefits, their deployment also increases electronic waste and energy demand, especially if not paired with green IT policies. Their survey of 30 firms in the Eleme industrial corridor of Port Harcourt highlighted the lack of e-waste management policies in most firms adopting digital technologies.

The economic impact of digital transformation has also been a key focus. Ijeoma and Brown (2022) reported that the integration of digital enterprise systems, such as ERP and CRM, led to substantial cost savings and productivity improvements among F&B firms in Port Harcourt. They observed a 15–20% increase in revenue growth and a reduction in operational delays after implementation. Their regression model indicated a statistically significant relationship between digitalization and economic performance ( $p < 0.01$ ).

Omoregbe et al. (2019) studied 22 food processing companies in Rivers and Bayelsa states and found that the adoption of digital financial systems like e-payment platforms and mobile banking improved cash flow, enhanced transaction transparency, and reduced fraud risks. However, the study also pointed out that initial costs of digital adoption, staff resistance, and inconsistent internet access remained major barriers to full economic benefit realization.

From a social sustainability angle, digital tools have been linked to improved employee engagement, customer interaction, and community development. Amadi and Johnson (2020) used a survey and focus group interviews among employees in 10 major beverage firms in Port Harcourt. Their findings showed that digital learning platforms and performance management software increased employee satisfaction and reduced turnover rates. Moreover, these tools enabled more equitable performance evaluations and skill-building opportunities.

Also, Nkereuwem and Nwachukwu (2023) evaluated the use of digital feedback tools (e.g., mobile surveys and online reviews) in food retail chains in Port Harcourt. The study concluded that firms utilizing such platforms had higher customer satisfaction and loyalty levels, which are critical social sustainability indicators. These tools helped firms better align products with customer expectations while addressing grievances more promptly.

Nonetheless, Odili and Opara (2021) warned that automation and digitization, if not managed inclusively, could lead to job losses among low-skilled workers in the food processing sector. Their study emphasized the importance of balancing digital efficiency with human capital development through upskilling programs.

### **Challenges to Digital Transformation for Sustainable Development**

Despite these benefits, studies highlight several challenges that hinder the full potential of digital transformation in Nigeria. Ekeh and Onwuzuruike (2023) identified issues such as inadequate digital infrastructure, high cost of broadband, and lack of digital skills as significant barriers. Similarly, Okonkwo (2022) noted that corruption and inconsistent government policies have slowed down digital initiatives, limiting their contribution to sustainable development.

### **Methodology**

**Research design:** This paper applied a descriptive and quantitative correlation approach,

**Population:** The population comprised of food and beverages firms in Port Harcourt, Rivers State, Nigeria.

**Sampling and Sampling Technique:** The combination of random sampling and purposive sampling technique were adopted. The food and beverages firms were selected using

purposive sampling technique, while random sampling was used to select 12 food and beverages firms in Port Harcourt. The sampling is 12 food and beverages firms in Port Harcourt, Rivers State Nigeria.

**Instrument of data collection:** The specific instrument used for collection of data in this paper is questionnaire. The questionnaire was patterned after an elaborate literature review. The questionnaire is of two section (A and B). Section A was designed to obtain data on the profile of the respondents such as age, sex, marital status, position, experience and educational qualification. Section B consist of the proxies of digital transformation and sustainable development of food and beverage firms in Port Harcourt, Rivers State.

**Validity:** To ensure the validity of the study, the questionnaire will be pre-tested with a small group of respondents from the target population. Feedback will be used to refine questions for clarity and relevance.

**Reliability:** Reliability was assessed using methods such as Cronbach’s alpha for the Likert-scale items in the questionnaire to ensure consistent measurement.

**Method of Data collection:** Questionnaire issued to respondents were retrieved and analyzed using descriptive statistics and correlation coefficient, using SPSS spread sheet for easy clarity.

**Data Analysis:** The quantitative data collected from the surveys will be analyzed using statistical software SPSS, while descriptive statistics will be used to summarize the demographic characteristics of respondents and their responses. Correlation coefficient was conducted to identify relationships and effects between digital transformation and sustainable development.

## Results

### Demographic analysis

**Table 1: showing the mean and median.**

		Gender	Qualifcation
N	Valid	12	12
	Missing	0	0
	Mean	1.25	3.25
	Median	1.00	3.00
	Std. Deviation	.452	.452

Source: field survey 2025

**Table 2: showing frequency of Gender.**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	9	75.0	75.0	75.0
	female	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

Source; Field survey 2025..

**Table 3: showing frequency of Qualification**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid B.sc	9	75.0	75.0	75.0
Masters	3	25.0	25.0	100.0
Total	12	100.0	100.0	

Source: Field survey 2025.

Figure 1: Bar chart showing gender.

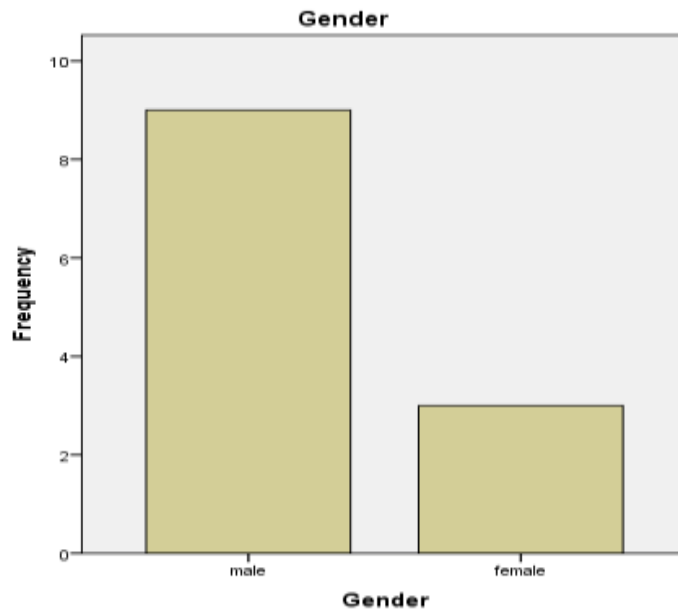


Figure 2: Showing pie chart of gender.

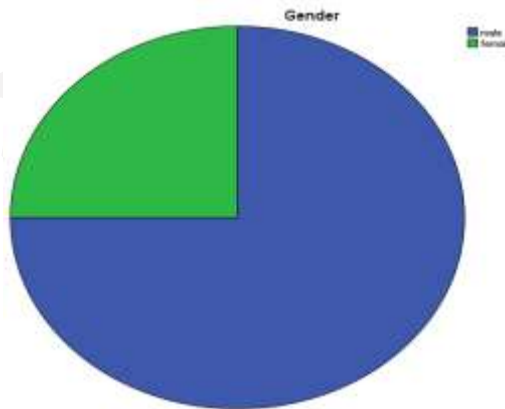


Figure 3: showing bar chart of qualification.

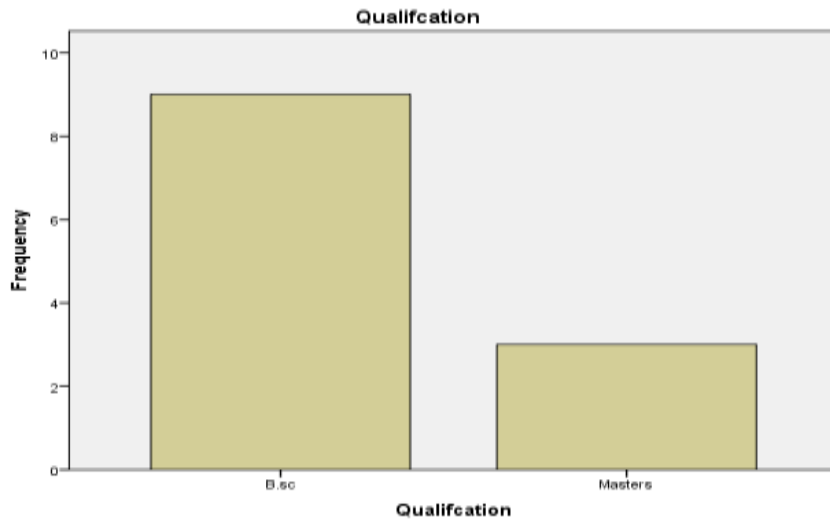
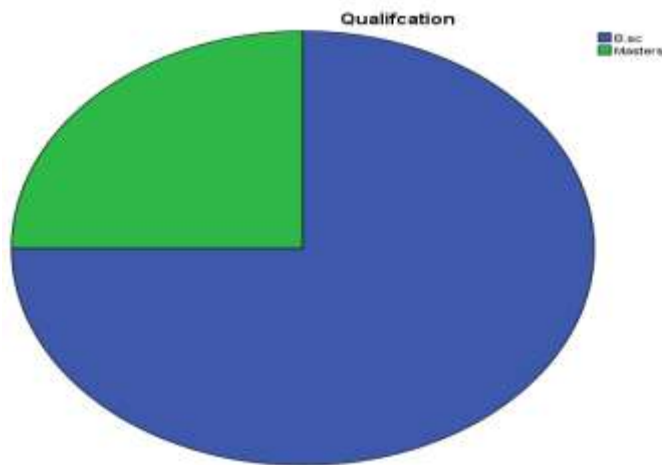


Figure 4: showing pie chart of qualification.



## Result

### Test of Hypothesis 1

H01: There is no relationship between digital transformation and Sustainability development of food and beverages firms in Harcourt.

### Correlations

		digital transformation	sustainability development.
digital transformation.	Pearson Correlation	1	1.000**
	Sig. (2-tailed)		.000
	N	12	12
sustainability development.	Pearson Correlation	1.000**	1
	Sig. (2-tailed)	.000	
	N	12	12

\*\* . Correlation is significant at the 0.01 level (2-tailed).

The correlation table above reveals the relationship between digital transformation and sustainability development of food and beverages firms in Port Harcourt. It shows that the correlation coefficient (r) is 1.000. This reveals that there is a strong relationship between digital transformation and sustainable development, with the implication sign value of (r) is positive while the p value is  $0.000 < 0.05$ . Therefore, we reject the null hypothesis and accept the alternative hypothesis, which implies there is a significant relationship between digital transformation and sustainability development of food and beverages firms in Port Harcourt.

## Hypothesis 2

H02: There is no relationship between sustainability practices and resource efficiency and reduction of environmental impact on food and beverage firms in Port Harcourt.

### Correlations

		digital transformation	Resource efficiency
Sustainability practice	Pearson Correlation	1	1.000**
	Sig. (2-tailed)		.000
	N	12	12
Resource efficiency	Pearson Correlation	1.000**	1
	Sig. (2-tailed)	.000	
	N	12	12

\*\* . Correlation is significant at the 0.01 level (2-tailed).

The correlation table indicates the relationship between sustainable practice and reduction in resource efficiency of food and beverages firms in Port Harcourt. It shows that the correlation coefficient (r) is 1.000. This reveals that there is a strong relationship between sustainable practices and resource efficiency with the implication sign value of (r) is positive while the p value is  $0.000 < 0.05$ . Therefore we reject the null hypothesis and accept the alternative hypothesis, which implies there is a significant relationship between and sustainability practice and resource efficiency of food and beverages firms in Port Harcourt.

## Discussion of Findings

This aspect discussed the findings obtained in the study regarding the hypothesized relationships and compared them with extant literature as to see if they are in agreement or not. Therefore, the discussion establishes the existence or non-existence of relationship between the variables in the hypotheses tested in the research.

### Digital Transformation and Sustainable development

One of the objectives of this study was to ascertain the relationship between Digital Transformation and Sustainable Development of Food and Beverage Firms in Port Harcourt. To what extent Digital Transformation relates to Sustainable Development. Digital Transformation was discovered to have a significant positive relationship with Sustainable Development of Food and Beverage Firms in Port Harcourt. This finding was generated from the outcome of the statistical test of hypotheses  $H_{01}$ . The test of  $H_{01}$  shows that Digital Transformation attracts a significant positive correlation coefficient ( $r = 1.000$ ,  $p\text{-value} < 0.05$ ). That is, the more food and beverage firm's utilizes Digital transformation the more they attain sustainable development

## Sustainable practices and Resource Efficiency

One of the objectives of this study was to determine the relationship between Sustainable practices and Resource Efficiency of Food and Beverage Firms in Port Harcourt. To what extent Sustainable practices and Resource Efficiency relates to Resource efficiency. Sustainable practices was discovered to have a significant positive relationship with Resource efficiency of Food and Beverage Firms in Port Harcourt. This finding was generated from the outcome of the statistical test of hypotheses  $H_{02}$ . The test of  $H_{02}$  reveals that Sustainable Practice attracts a significant positive correlation coefficient ( $r = 1000$ ,  $p\text{-value} < 0.05$ ). That is, the consistent food and beverage firm's utilizes Digital transformation the more they attain sustainable development.

## Conclusion

This growing body of literature collectively highlights the critical role that digital transformation can play in achieving broader sustainable development goals. We can see from the results that there is strong relationship between digital transformation and sustainable development in food and beverages firms in Port Harcourt.

## Recommendations

1. Firms should prioritize investing in advanced technologies such as artificial intelligence, IoT, and robotics to streamline operations.
2. Training programs should be planned, organized and implemented to equip employees' with the skills needed to utilize digital technologies effectively.
3. Government policies should be directed towards addressing infrastructural gaps and provide incentives for firms embracing digital transformation.
4. There should be strategic partnership in collaboration with technological firms in other to ease the adoption of digital tools.

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# Challenges and Prospects of the SIWES Programme for Students in the School of Environmental Studies of the Oke-Ogun Polytechnic, Saki, Oyo State, Nigeria

Sanni Tawakalitu Bolanle<sup>1</sup>, & Olatunji Daniel Abiodun<sup>2</sup>

<sup>1</sup>Industrial Liaison and Placement Office, The Polytechnic, Ibadan

<sup>2</sup>Department of Urban and Regional Planning, University of Ibadan, Nigeria

Email: [tawakalitbolanle2015@gmail.com](mailto:tawakalitbolanle2015@gmail.com)<sup>1</sup>, [dolatunji249644@stu.ui.edu.ng](mailto:dolatunji249644@stu.ui.edu.ng)<sup>2</sup>

## ABSTRACT

*The study examined the challenges and prospects of SIWES to learners in the Faculty of Environmental Studies in the Oke-Ogun Polytechnic, Saki in Oyo State, Nigeria. It had a descriptive survey design and sampled 150 ND II students in 7 departments through stratified random sampling. Structured questionnaire was used to collect data. ANOVA and t-test at 0.05 level of significance were used in descriptive analysis. Findings revealed average problems where accommodation problems, failure to pay allowances, and problems with placing had the highest problems. Supervision based in industry was okay, whereas the institution-based visit was next to none. Relevancy of placements was found, especially with employability, but with the restricted use of specialization projects. The students were positive regarding the possibility of improvement (cluster mean = 3.37), giving allowance payment (mean = 3.62), accommodation support (mean = 3.58) and sanctioning of exploitative organizations (mean = 3.52). There was no significant difference in challenges between departments ( $F = 2.146$ ,  $p = 0.052$ ), but as far as the supervision is concerned, there was also a significant benefit of the placements in the private sector ( $t = 2.682$ ,  $p = 0.008$ ). There was no gender differences found in prospect perception ( $t = -0.342$ ,  $p = 0.733$ ). The research finds structural problems and institutional supervision failures to be the limiting factor to the effectiveness of SIWES. Some of the recommendations are advancing control by creating systematic visitation schedules, engaging in regulatory fines, creating accommodation support, and emphasizing the placement of the private sector.*

KEYWORDS: SIWES, challenges, prospects, environmental studies, supervision, polytechnic education, Oyo State, Nigeria

## 1. INTRODUCTION

To address the issue of inadequate practical skills among tertiary institution graduates in Nigeria, in 1973, the Industrial Training Fund (ITF) developed the Students' Industrial Work Experience Scheme (SIWES) (Omonijo et al., 2019). The scheme bridges the gap between theory and the practical aspect of an industry, subjects students to the working environment with equipment, builds a relationship between the institution and industry, and makes graduates self-reliant (Madu et al., 2023). SIWES is the first experience to the targeted career to most students (Chukwuedo, 2011).

The Faculty of Environmental Studies that comprises of Architecture, Building Technology, Estate Management, Quantity Surveying, Surveying and Geoinformatics, Urban and Regional

Planning, and Transportation Planning and Management is a practically based institution. The students require practical experience on building, appraisals, surveying and planning that cannot be adequately simulated in the classrooms. As it can be seen by Ibrahim et al. (2024), the inadequacy of the graduate of Built Environment in Nigeria can be partially attributed to the difficulties that the students experience during SIWES, and this is why it is important to study the problems.

Academic performance refers to the capacity of the students to achieve the educational goals and it is normally measured by the grade point average (Ademiluyi and Ademiluyi, 2018; Steinmayr et al., 2014). As the past studies have demonstrated, SIWES positively influences the academic performance, and Madu et al. (2023) state that 93.7 percent of students enrolled in the Library and Information Science courses have testified to improved grades after having taken part in SIWES. It has also been reported by Chukwuedo (2011) that competency and learning in classroom post industrial attachment also increase.

The Faculty of Environmental Studies of The Oke-Ogun Polytechnic, Saki (TOPS) requires students of SIWES. However, according to anecdotal reports, the setbacks are the irrelevance of placements, inadequate supervision, absence of equipment exposure, housing problems, non-payment of allowances and menial job performance. He mentioned poor placement mismatches and poor supervision as a hindrance to the effectiveness of SIWES, but Sulyman et al. (2024) focused on poor funds, inefficient supervision, and low motivation among lecturers as the key issues.

The study will be useful to address the gaps in the relationship between the objectives of SIWES and the real life experiences of the students in TOPS where very little empirical studies have been done. It discusses the challenges of placement, nature of supervision, relevance of placements and opportunity to improve the environmental studies students.

The students, academic personnel, ITF, polytechnic management and host organisations and the researchers in the study will find the findings useful as they will provide empirical evidence on policy decision-making and intervention to facilitate higher performance of SIWES. The study is aimed at final year students and those students can provide informed answers after undergoing their SIWES programme.

## **2. LITERATURE REVIEW**

### **2.1 Conceptual Framework**

#### **Students Industrial Work Experience Scheme (SIWES) Concept.**

Students Industrial Work Experience Scheme (SIWES) is a skill training programme that was created by the Industrial Training Fund (ITF) in 1973, to respond to the alarm about the lack of practical skills in the graduates of the tertiary institutions in Nigeria. According to Madu et al. (2023), SIWES is a type of educational programme where students get to work during their time in school, enabling them to participate in the real job setting. According to Simisaye et al. (as cited in Madu et al., 2023), it is a professional education stage during which undergraduates receive hands-on training in the area of their study.

The goals of the ITF in SIWES are exposing students to equipment handling processes that are not provided in the learning institutions; training the instructors on the developments in the industries; building institution-industry relationships; engaging the employers in the learning process; preparing the students to work in industries; bridging the gap between theory and practice; and achieving self-reliance through the combination of analytical and practical skills (Madu et al., 2023). Omonijo et al. (2019) observe that the realization of these

objectives should bring quantifiable positive changes in the classroom performance of students.

Tertiary institutions have the SIWES Directorate that organises the placement of students, their supervision and monitoring, documentation in logbooks, assessment during oral presentation, contact with the regulatory authorities and collection of feedback to improve continuously.

### **Academic Performance Concept.**

Academic performance is the ability of students to attain educational objectives, which imply the ability of learners to satisfy institutional or educational authority requirements (Ademiluyi and Ademiluyi, 2018). According to Steinmayr et al. (2014), it is the knowledge level that has been shown in a field in relation to the norm, which is measured using grade point average. Lamas (2015) characterizes academic performance as learning outcomes that are the result of teaching action, which is indicative and responsive skills of what an individual has acquired during education.

York et al. (2015) observe that the academic performance involves the learning processes that convert a certain state to a different state, depending on circumstances and environmental conditions that define skills and experiences.

### **Faculty of Environmental Studies and SIWES.**

The Faculty of Environmental Studies includes the disciplines that are based on the practical application: Architecture, Building Technology, Estate Management, Quantity Surveying, Surveying and Geoinformatics, Urban and Regional Planning, and Transportation Planning and Management. Construction and property industries need special skills to the students. As Ibrahim et al. (2023) note, some of the problems that Nigerian Built Environment graduates are not able to overcome can also be explained by the problems that students encounter during SIWES. According to Ojokuku et al. (2015), practically oriented studies have the advantage of balancing the theory in the classroom with practice.

## **2.2 Theoretical Framework**

### **Experiential Learning Theory.**

The Experiential Learning Theory by Kolb (1984) assumes that knowledge is born as a result of experience transformation. Learning goes on through a cycle of concrete experience, reflection, abstract conceptualisation and active testing in which students advance. SIWES helps achieve this cycle by offering direct industrial experience, which must be documented and reflected in the form of logbooks, conceptual understanding, and application of the knowledge on the return to the academic studies.

### **Human Capital Theory**

Human Capital Theory as put forward by Schultz (1961) and Becker (1964) assumes that education and training is an investment that increases personal productivity and economic growth. Educational attained skills are capital to be returned in future. Practical skills, professional competencies, and industry exposure in the context of the SIWES are human capital investments, which enhance academic performance, employability and contribution to national development. According to Effah et al. (2014), SIWES expands the learning settings beyond the school capacity.

## **2.3 Empirical Review**

### **Effects of SIWES on Academic Performance.**

Madu et al. (2023), who examined the Library and Information Science students in Osun State, discovered that SIWES has a positive impact on academic performance, and 93.7% of the respondents confirmed this impact and a significant improvement in CGPA after SIWES. According to Chukwuedo (2011), SIWES had a positive impact on academic performance in University of Benin and improved competency of workshops and classroom learning. Ademiluyi and Ademiluyi (2018) established that SIWES had a significant impact on the performance of Office Technology and Management students in word processing. Daramola (2025) observed that skill development, type of industry, placement and supervision had a great influence on academic performance in the private polytechniques. Duignan (2003) however warns that work experience may not necessarily result to improved academic performance whose outcomes are mediated by the quality of supervision, relevance of placement and student engagement.

### **SIWES Implementation difficulties.**

According to Ibrahim et al. (2023), commitment of the instructors, duration of the programme, lack of training materials, allocation of trivial tasks, and awkward working conditions have been pointed out as some of the greatest difficulties facing built environment students. Oyeniyi (2012) established that SIWES helped in the achievement of skills, but numerous challenges reduced its efficiency. According to Anyaeneh and Ochuba (2019), the challenges found were finance, placement issues, inefficient supervision, and inconsistent academic schedules.

According to Effah et al. (2014) there was bad industry-based supervision, limited access to equipment, limited training sessions and unfriendly attitudes of workers. Accommodation difficulties and lack of staff commitment were also included by Karunaratne and Perera (2015). A study by Sulyman et al. (2024) revealed a lack of sufficient funds, ineffective supervision, nonchalance among students, lack of time, and the motivation of lecturers. Inadequate supervision, mismatch of placement, and restricted access to equipment were the factors that weakened the potential of SIWES (Yusuf, 2025).

### **Future opportunities of SIWES.**

In the recent changes, ITF has been undertaking initiatives to clear the unpaid stipend backlogs, timely disbursement, coordination of supervision, and use of electronic logbook systems that have lessened financial strain and enhanced tracking (Oladimeji, 2024). Policy making is also involving students, and the aspect of fraud and exploitation is minimized. The capacity-building workshops are held by institutions; the University of Port Harcourt has conducted a training on supervision, ethical behaviour and documentation. These new models include discipline-specific incubation and capstone projects that are practical (Ajilore, 2024).

## **3. METHODS**

### **3.1 Study Area**

The Oke-Ogun Polytechnic, Saki (TOPS) is located in Saki, headquarters of Saki West Local Government Area of Oyo State, Nigeria. The institution was erstwhile The Polytechnic Ibadan, Saki Campus, before its autonomy pronouncement in 2014 by the late Senator Isiaka Abiola Ajimobi, which established it as an independent institution. The polytechnic commenced academic activities in 2008/2009 and operates two campuses. The Faculty of Environmental Studies comprises seven departments: Architecture, Building Technology, Estate Management and Valuation, Quantity Surveying, Surveying and Geoinformatics, Urban and Regional

Planning, and Transportation Planning and Management. Students participate in SIWES at the end of their ND I programme for four months.

### 3.2 Data Collection

The descriptive survey design was utilized. The sample size will include the ND II students in Faculty of Environmental Studies at TOPS in 2024/2025 in seven departments. The ND II students were selected because they have already gone through their SIWES programme. The sample size was decided by Taro Yamane formula at 0.05 margin of error to give a sample of 162 respondents. Proportional stratified random sampling was used. It was a structured questionnaire named Questionnaire on Challenges and Prospects of SIWES on the Students of the Faculty of Environmental Studies which was developed based on literature (Madu et al., 2023; Ibrahim et al., 2023; Chukwuedo, 2011). The questionnaire had five sections of 45-item Likert scale. Three experts were used to validate the instrument. Data collection was done using person administration in a span of two weeks. Informed consent was given verbally, and the confidentiality assured.

### 3.3 Analytical Methods and Procedure of Sampling

Multi-stage sampling was employed: Oyo State and TOPS were purposively selected; the Faculty of Environmental Studies was purposively chosen; all seven departments were included; and respondents were selected through stratified random sampling with proportional allocation. Data were analyzed using SPSS version 26.0. Descriptive statistics of frequency, percentage, mean, and standard deviation answered research questions. The cut-off mean was 2.50. ANOVA tested differences in challenges across departments at 0.05 significance level. Reliability testing exceeded the 0.70 threshold.

## 4. RESULTS

### 4.1 Demographic Profile of Respondents

As shown in Table 1, men were 65.3 percent and women 34.7 percent, which is gender proportional to the environment studies programmes of the Nigerian polytechnics. Most of them (52.0%) were aged between 22-25. There was a sufficient representation of all the seven departments. The majority of students (74.7) did SIWES in the organizations in the private sector, and 64.7% completed the attachment in Oyo State.

**Table 1: Demographic Characteristics of Respondents**

Variable	Category	Frequency (N=150)	Percentage (%)
Gender	Male	98	65.3
	Female	52	34.7
Age	18-21 years	42	28.0
	22-25 years	78	52.0
	26-30 years	24	16.0
	Above 30 years	6	4.0
Department	Architecture	22	14.7
	Building Technology	24	16.0
	Estate Management and Valuation	20	13.3
	Quantity Surveying	19	12.7
	Surveying and Geoinformatics	21	14.0
	Urban and Regional Planning	20	13.3

	Transportation Planning and Management	24	16.0
Placement Type	Private Sector Organization	112	74.7
	Public Sector Organization	38	25.3
Location of Placement	Within Oyo State	97	64.7
	Outside Oyo State	53	35.3

**Source: Authors Fieldwork, 2025.**

#### 4.2 Challenges Facing Students During SIWES

Table 2 indicates that 11 of 15 challenge items showed a mean score of above the cut-off point of 2.50 and 4 items were below the cut-off point. The mean of the cluster of 2.93 means that students are moderately challenged at the process of SIWES. The most ranked challenges were accommodation challenges (mean = 3.64), non-payment of upkeep allowance (mean = 3.56), engaging students in menial jobs (mean = 3.42), and the inability to find a relevant placement (mean = 3.28). The items that were rejected as the major challenges were poor industry-based supervision (mean = 2.46), security concerns (mean = 2.38), unfriendly staff attitude (mean = 2.42) and the inability to get the logbook signed (mean = 2.34) indicating that these are not widespread problems amongst most students.

**Table 2: Mean Ratings of Challenges Facing Students During SIWES**

S/N	Challenge Items	Mean	Std. Dev.	Decision
1	Difficulty in securing relevant industrial placement related to my field of study	3.28	0.74	Accepted
2	Non-payment of upkeep allowance by host organization	3.56	0.62	Accepted
3	Accommodation challenges at the place of attachment	3.64	0.58	Accepted
4	Inadequate supervision from institution-based supervisors	2.84	0.86	Accepted
5	Inadequate supervision from industry-based supervisors	2.46	0.92	Rejected
6	Engaging students in menial tasks unrelated to course of study	3.42	0.69	Accepted
7	Short duration of SIWES programme for adequate skill acquisition	3.08	0.82	Accepted
8	Lack of modern equipment and facilities at placement organization	3.18	0.77	Accepted
9	Security concerns at the location of attachment	2.38	0.94	Rejected
10	Irregular academic calendar affecting SIWES timing	2.92	0.84	Accepted
11	Transportation difficulties to and from workplace	3.06	0.79	Accepted
12	Unfriendly attitude of staff towards trainees	2.42	0.91	Rejected
13	Lack of proper induction/orientation at the beginning of placement	3.22	0.73	Accepted
14	Difficulty in getting logbook signed regularly	2.34	0.96	Rejected
15	Inadequate training resources at placement organization	3.14	0.78	Accepted
	<b>Cluster Mean</b>	<b>2.93</b>		

**Source: Authors Fieldwork, 2025.**

#### 4.3 Nature of Supervision Received During SIWES

Table 3 indicates that the mean scores of 8 out of 10 supervision items were above the cut-off point of 2.50, with the scores ranging between 2.58 and 3.34, and two items below the cut-off. The average cluster of 2.65 indicates an average quality of supervision. The best rated supervision areas were industry-based supervisor knowledge (mean = 3.34), supervision that boosts practical skills (mean = 3.24) and industry-based supervisor guidance (mean = 3.12). Nonetheless, two items were also highly rejected which included institution-based supervisor visitation (mean = 1.68) and effective communication between institution and placement organization (mean = 1.94). This implies that the level of industry-based supervision is relatively satisfactory, but institution-based supervision is practically nonexistent as the majority of students do not have a visit by their school supervisors within the attachment period.

**Table 3: Mean Ratings of Nature of Supervision Received During SIWES**

S/N	Supervision Items	Mean	Std. Dev.	Decision
1	My industry-based supervisor provided regular guidance and mentorship	3.12	0.76	Accepted
2	My institution-based supervisor visited me at my placement location	1.68	0.88	Rejected
3	I received adequate feedback on my performance from supervisors	2.72	0.84	Accepted
4	My industry-based supervisor was knowledgeable and experienced in my field	3.34	0.68	Accepted
5	I was assigned specific tasks with clear learning objectives	2.88	0.81	Accepted
6	My supervisor conducted regular assessment of my work	2.94	0.79	Accepted
7	There was effective communication between my institution and placement organization	1.94	0.86	Rejected
8	My industry-based supervisor was committed to my training	3.06	0.74	Accepted
9	I received supervision at least once weekly during the attachment	2.58	0.89	Accepted
10	The supervision I received enhanced my practical skills development	3.24	0.71	Accepted
	<b>Cluster Mean</b>	<b>2.65</b>		

**Source: Authors Fieldwork, 2025.**

#### **4.4 Relevance of SIWES Placement to Fields of Study**

Table 4 shows that 9 of the 10 relevance items were above the cut-off point of 2.50 with a range of 2.64 to 3.42, and one item was below the cut-off point. The average of the cluster of 3.02 means that students rated their SIWES placements as applicable in their disciplines, not with an overwhelmingly high score. The most relevant aspects were rated as highest, and included that SIWES experience will improve employability (mean = 3.42), skills gained are relevant to the requirements of an ND programme (mean = 3.28), and that practical skills gained will be useful in the future career (mean = 3.22). The rejected item was the opportunity to work on projects based on specialization (mean = 2.48) indicating that although placements expose students to the industry in general, they do not necessarily do any specialized project work that is directly connected to their concentration areas.

**Table 4: Mean Ratings of Relevance of SIWES Placement to Fields of Study**

S/N	Relevance Items	Mean	Std. Dev.	Decision
1	My SIWES placement was directly related to my course of study	3.08	0.78	Accepted
2	I was exposed to equipment and technologies relevant to my profession	2.86	0.84	Accepted
3	The tasks I performed aligned with my classroom learning	2.64	0.89	Accepted
4	I acquired practical skills applicable to my future career	3.22	0.72	Accepted
5	The experience improved my understanding of theoretical concepts	3.16	0.74	Accepted
6	My placement exposed me to current industry practices in my field	3.04	0.79	Accepted
7	I was able to apply knowledge gained in school to real work situations	2.98	0.81	Accepted
8	The skills I acquired are relevant to my ND programme requirements	3.28	0.70	Accepted
9	My SIWES experience will enhance my employability after graduation	3.42	0.64	Accepted
10	I had opportunities to work on projects related to my specialization	2.48	0.93	Rejected
	<b>Cluster Mean</b>	<b>3.02</b>		

**Source: Authors Fieldwork, 2025.**

#### 4.5 Prospects for Improving the SIWES Programme

As shown in Table 5, all 10 prospect items scored above the cut-off point of 2.50 with a range of 2.96 to 3.62, which depicts that the respondents agreed on the prospects of enhancing the SIWES programme. The highest cluster mean of 3.37 is observed in all the sections which implies that students have a positive expectation on the possibility of improvement. The prospects that were rated as highest were that they would pay allowances on time (mean = 3.62), that they would support students through provision of accommodation (mean = 3.58), that they would sanction institutions that exploit students (mean = 3.52), that they would strengthen supervision by visiting the institution regularly (mean = 3.48), and that they would ensure placements were appropriate to fields of study (mean = 3.44). The shortest mean (2.96) was with the extension of SIWES, which implies that students find it less valuable when it is longer but find other aspects more important to improve at that point.

**Table 5: Mean Ratings of Prospects for Improving SIWES Programme**

S/N	Prospect Items	Mean	Std. Dev.	Decision
1	Strengthening supervision through regular institution visits to students	3.48	0.63	Accepted
2	Ensuring timely payment of allowances by host organizations	3.62	0.56	Accepted
3	Providing accommodation support or allowance for students	3.58	0.59	Accepted
4	Extending duration of SIWES for better skill acquisition	2.96	0.83	Accepted
5	Establishing stronger partnerships between polytechnic and relevant industries	3.38	0.68	Accepted

6	ITF providing better oversight and monitoring of student placements	3.26	0.72	Accepted
7	Ensuring placements match students' fields of study	3.44	0.65	Accepted
8	Providing pre-SIWES orientation and preparation for students	3.32	0.70	Accepted
9	Adoption of electronic logbook system for easier documentation	3.14	0.76	Accepted
10	Sanctioning organizations that exploit SIWES students	3.52	0.61	Accepted
<b>Cluster Mean</b>		<b>3.37</b>		

**Source: Authors Fieldwork, 2025.**

#### 4.6 Summary of Findings Across Departments

Table 6 reveals that the Building Technology students experienced the most challenges during SIWES (mean = 3.16), then Quantity Surveying (mean = 3.08) and lastly Estate Management and Valuation (mean = 3.02). Students of Urban and Regional Planning showed the least challenges (mean = 2.68). This difference indicates that construction related fields might have more challenges when it comes to industrial attachment perhaps because of the type of construction sites and working environments.

**Table 6: Distribution of Challenge Mean Scores by Department**

Department	N	Mean Challenge Score	Rank
Building Technology	24	3.16	1st
Quantity Surveying	19	3.08	2nd
Estate Management and Valuation	20	3.02	3rd
Transportation Planning and Management	24	2.94	4th
Architecture	22	2.88	5th
Surveying and Geoinformatics	21	2.79	6th
Urban and Regional Planning	20	2.68	7th

**Source: Authors Fieldwork, 2025.**

#### 4.7 Hypothesis Testing

**H<sub>0</sub>1:** There is no significant difference in the challenges faced by students during SIWES across the seven departments in the Faculty of Environmental Studies at The Oke-Ogun Polytechnic, Saki.

Table 7 shows that the calculated F-value is 2.146 at p-value of 0.052 which is a little bit higher compared to the level of significance of 0.05. So, there is no rejection of the null hypothesis. It means that the difference in the challenges encountered by students during SIWES in the seven departments is not statistically significant. Though descriptive statistics revealed that there was a range of mean scores, the difference is not significant at the 0.05 level meaning that the challenges are quite similar in all the disciplines of environmental studies.

**Table 7: ANOVA Summary Table for Differences in Challenges Across Departments**

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.	Decision
Between Departments	3.124	6	0.521	2.146	0.052	Not Significant
Within Departments	34.726	143	0.243			
Total	37.850	149				

**Source: Authors Fieldwork, 2025.**

**H<sub>0</sub>2:** There is no significant difference in the perception of supervision received during SIWES between students placed in private and public sector organizations.

Table 8 indicates that students who were in the private sector organizations experienced a much higher perception of quality of supervision (mean = 2.74) than those in the public sector organizations (mean = 2.38). The t-value of 2.682 with a p-value of 0.008 ( $p < 0.05$ ) shows that the difference is statistically significant. Thus, null hypothesis is rejected. This observation indicates that the quality of supervision in the course of SIWES is higher in the case of the private sector organizations as compared to the case of the public sector establishment.

**Table 8: t-Test Summary for Differences in Supervision Perception by Placement Type**

Placement Type	N	Mean	Std. Dev.	df	t	Sig.	Decision
Private Sector	112	2.74	0.62	148	2.682	0.008	Significant
Public Sector	38	2.38	0.74				

**Source: Authors Fieldwork, 2025.**

**H<sub>0</sub>3:** There is no significant difference in the perception of prospects for improving SIWES between male and female students.

Table 9 shows that the female students had a slightly better perception of the opportunities to improve SIWES (mean = 3.39) than the male students (mean = 3.36). It is however not statistically significant because the t-value of -0.342 has a p-value of 0.733 ( $p > 0.05$ ). That is why, the null hypothesis is not rejected. This result indicates that both the male and female students have common opinions on the future of enhancing the SIWES programme.

**Table 9: t-Test Summary for Differences in Prospect Perception by Gender**

Gender	N	Mean	Std. Dev.	df	t	Sig.	Decision
Male	98	3.36	0.54	148	-0.342	0.733	Not Significant
Female	52	3.39	0.49				

**Source: Authors Fieldwork, 2025.**

## 5. DISCUSSION

This research study presents a multifaceted image of the SIWES application to students of environmental studies at The Oke-Ogun Polytechnic, Saki, with a lot of challenges that limit the potential of the scheme but still students derive value in an experience. The reported moderate level of challenges (cluster mean = 2.93) corresponds to national trends reported by Madu et al. (2023) and Ibrahim et al. (2024), who also placed accommodation challenges, non-payment of allowances, and working on menial tasks as the widespread issues in Nigerian institutions. Accommodation issues (mean = 3.64) and non-payment of allowances (mean = 3.56) are the dominant problems, which reflect the underlying economic vulnerabilities in the face of which students in the less fortunate backgrounds may find participation in industrial attachment costly than potentially beneficial. The finding of students getting engaged in menial work irrelevant to their course of study (mean = 3.42) supports Ibrahim et al. (2024), who also discovered that this was one of the biggest challenges facing built environment students, implying that the host organizations might have operational requirements, at the expense of developmental goals, which is the core intention of SIWES.

Supervision is such that it indicates a terrible institutional failure that is disguised by fairly sufficient oversight in the form of industry-based supervision. As compared to the industry-based supervisors who scored well in their knowledge (mean = 3.34) and guidance (mean =

3.12), the institution-based supervisor visitation was almost zero (mean = 1.68), and there was also poor communication between institution and the placement organization (mean = 1.94). The result supports Madu et al. (2023), who have observed that school supervisors visit students practically never, and Sulyman et al. (2024), who have listed ineffective supervision as a central issue. The quality of supervision between the private and public sector placements ( $t = 2.682$ ,  $p = 0.008$ ) with the better supervision provided by the former, argues that competitive pressures can make the more committed to training in the private companies. The result is that there is no system to check on the experiences of students or to intervene when things go wrong and leave students alone in the attachment phase of life.

Nevertheless, students find their SIWES placements to be relevant to their disciplines (cluster mean = 3.02) especially in enhancing employability (mean = 3.42) and skills acquisition as required by the ND programmes (mean = 3.28). This observation is in line with Adegbite et al. (2025) who also affirmed that SIWES strengthens the competencies of employability and Chukwuedo (2011) who found positive effects on academic performance. Nevertheless, the refusal to accept the chances to work on specialization-specific projects (mean = 2.48) reveals the boundaries to this applicability, and Yusuf (2025) on the incompatibility between placement and field of study. This implies that although students have the overall industry exposure, they are not usually involved in the specialized work that is at the core of their professional development, which is a severe deficiency in skill development of the environmental studies disciplines.

Students were very optimistic regarding the chances of improvement (cluster mean = 3.37), and the priorities were directly connected to the challenges identified, including timely payment of allowances (mean = 3.62), accommodation support (mean = 3.58), sanctioning exploitative organizations (mean = 3.52), strengthened supervision (mean = 3.48), and placement relevance (mean = 3.44). The necessity of the sanctions against exploitation organizations encourages Ogbuanya et al. (2018) regarding the need to introduce more effective enforcement strategies, whereas the demand to visit the institution indicates that the students are aware of the existing supervisory vacuum. The lower scores on the extension of SIWES time (mean = 2.96) hint at the fact that students are focused on improvements in quality rather than quantity, which is a subtle point that may be used to discuss policies. The same is supported by the lack of substantial gender differences in prospect perception ( $t = -0.342$ ,  $p = 0.733$ ) and Simisaye et al. (2018) on gender similarity in SIWES perceptions. All these findings point to the fact that although SIWES implementation at TOPS is fraught with challenges, the students understand the value of its provision, and they have an idea of what should be done to improve the scheme to turn it into the transformational experience that it was created to be.

## **6.0 CONCLUSION AND RECOMMENDATIONS**

### **6.1 Conclusion**

The research offers solid empirical evidence on the issues and opportunities of the student's industrial work experience Programme (SIWES) to students in the Faculty of Environmental Studies at The Oke-Ogun Polytechnic, Saki. The results obtained with the help of a sample of 150 ND II students in seven departments show that SIWES is still a relevant and appreciated part of environmental education, especially in terms of improving employability and gaining programme-relevant skills but its implementation is spoiled by serious structural issues. The most serious challenges that students faced were accommodation problems, failure to pay upkeep allowances, working at menial jobs that were not related to the course of study, and inability to get proper placements. In the study, a vital institutional failure has been revealed: industry-based supervision is somewhat acceptable, but there is practically no institution-

based supervision, so the majority of students have never been visited by the school supervisors during attachment. Such supervisory vacuity undermines quality assurance and leaves students alone to work through the challenges without the support of the institution. In spite of these limitations, students are highly optimistic regarding the improvement opportunities, and their priorities are directly oriented to the challenges that have been identified. The contingent status of the quality of supervision by the type of placement sector, where private organizations provide much higher quality supervision, and the almost significant differences in the amount of challenge by department indicate that the results of SIWES are influenced by several institutional, organizational and disciplinary factors. After all, the issues recorded are not unavoidable but are indicative of fixable flaws in policy execution, institutional dedication and regulatory enforcement that, once amended, would likely turn SIWES into the paradigm shift it was intended to be.

## **6.2 Recommendations**

### **Institutional-Level Interventions**

The Oke-Ogun Polytechnic, Saki management should be keen on enhancing the institutional based supervision by laying emphasis on providing budgetary allocations to supervision visits, supervision schedules in which all students have at least one supervision visit and formal communications protocol with host organizations. The polytechnic must also establish departmental databases of approved placement organizations to overcome the issue of placement relevance as well as to reinforce the pre-SIWES orientation programmes.

### **Regulation and Enforcement Systems.**

The Industrial Training Fund (ITF) must have a centralized reporting system on student grievances, regularly audit host organizations and have significant sanctions in place, such as delisting and public disclosure on organizations that default on SIWES guidelines, especially in non-payment of allowances and exploiting students.

### **Welfare Support and Accommodation.**

Considering accommodation issues as the greatest problem, collaborative programs between ITF, polytechnic, and host organizations ought to provide accredited hostel facilities in key areas of placement, enter into accommodation agreements as part of placement contracts, and give accommodation allowances to the students.

### **Placement Strategy Improvement.**

The polytechnic needs to focus on building relations with private sector bodies because they are far superior in terms of quality of supervision whereas collaborating with the state bodies to enhance their culture. Placement databases should be department specific to have the students placed in organizations that can offer training that meets the requirements of the curriculum.

### **Systemic Policy Reforms**

Timely payment of allowances, tax incentives to organizations offering quality supervision and more funding on SIWES coordination should be included in the legislation that should be considered by the federal and state governments. An effective feedback-gathering and continuous improvement mechanism must be instituted on a regular basis and with the help of a monitoring and evaluation mechanism. These mutually supportive interventions have the potential to be implemented in a systematic way to tackle the recognized challenges and make SIWES effective in the work of environmental studies students.

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# Gender Inclusion Through AI-Driven Technology: Breaking Barriers and Bridging Gaps

**Fowowe Oluwadarasimi Oyindamola<sup>1</sup> & Kuwanta Grace<sup>2</sup>**

<sup>1</sup>Department of Industrial Technology, Faculty of Technology and Industrial Studies  
Rev. Fr. Moses Orshio Adasu University, Makurdi

<sup>2</sup>College of Education, Akwanga, Nasarawa State

## **ABSTRACT**

*Artificial Intelligence (AI) is rapidly transforming educational systems worldwide. Accordingly, this paper explores how AI-driven technology education can promote gender inclusion by breaking down historical barriers and creating equitable access to learning opportunities. Specifically, it reviewed the effects of AI on women's empowerment in the in the society today with a bias for core Northern states in Nigeria. It critically examines the challenges women face in technology education and STEM as well as evaluates how AI can serve as a tool to bridge the digital and gender divide. It probes into AI's capacity to close gender gaps, enhance technical education and to promote gender parity by recommending ways to achieve gender inclusion in line with global best practices that support inclusive AI-enhanced education. The paper took the part of examining few case studies and initiatives which underscore the potential benefits and hurdles associated with AI in propelling gender inclusion and women empowerment. The results indicate that while AI holds promise for advancing women's empowerment, it necessitates diligent efforts to mitigate biases and uphold inclusivity.*

**KEYWORDS:** Artificial Intelligence, Educational Equity. Education Technology and Gender Inclusion.

## **1.0 Introduction**

Generally, technology education has long been associated with gender disparity, particularly with the underrepresentation of women in STEM fields. Noteworthy is that this scenario is made possible by societal expectations and believe that one gender has more physical strength and acumen for technological task than the other. However, the advent of artificial intelligence (AI) brings with it new opportunities to address these disparities through personalized, accessible, and inclusive learning tools capable of reshaping how knowledge is delivered, how learners engage with content, and how educators monitor and support academic progress (Luckin et al., 2016). In recent years, Artificial Intelligence (AI) has emerged as a potent force capable of reshaping numerous facets of society. Within Nigeria, a nation grappling with entrenched gender disparities and social hurdles, AI stands poised to wield substantial influence in advancing women's empowerment. Gender inclusion in Technical and Vocational Education and Training in North West Nigeria experiences constraints, primarily orchestrated by deep-seated socio-cultural and religious norms, early marriage, and patriarchal views that marginalize women in technical fields. Despite strides made towards women's empowerment in this diverse and culturally vibrant country like Nigeria, persistent gender inequities endure across key domains such as education and technology. Deep-rooted societal biases, unequal access to resources, and limited opportunities continue to impede the advancement of women throughout the nation.

AI applications such as intelligent tutoring systems, automated assessments, and personalized learning environments are increasingly being deployed in educational settings across the world. While these developments bring numerous benefits, they also raise critical questions about equity, particularly in relation to gender and inclusion in technology education.

Gender disparities in education, especially within science, technology, engineering, and mathematics (STEM), have been a longstanding global concern. According to UNESCO (2017), women represent less than 30% of the STEM workforce worldwide, a figure that reflects systemic exclusion rather than a lack of ability or interest. This underrepresentation is rooted in multiple factors, including cultural and social norms, lack of female role models, gender-biased curricula, limited access to digital tools, and institutionalized discrimination. These barriers are particularly pronounced in low-income and developing countries, where educational inequality is exacerbated by poverty, infrastructural deficits, and restrictive gender roles (UNESCO, 2021).

## **2.0 Conceptual Clarification**

### **2.1 Gender Inclusion**

Gender equality is a state in which people have access to rights or opportunities regardless of gender. Gender-inclusive language is speaking and writing in a way that does not discriminate against a particular sex, social gender or gender identity, and does not perpetuate gender stereotypes. Gender inclusion can also be referred to efforts and practices that ensure equal participation, access, and outcomes for individuals of all gender identities in educational, economic, and social contexts (UNESCO, 2020). Therefore, Inclusion generally strives to make all people feel valued and respected. With respect to the title of this paper, Gender inclusion in Technical and Vocational Education means ensuring everyone, regardless of gender, has equal opportunities to acquire skills and pursue careers in tech and vocational fields. It's about breaking down barriers and stereotypes that might limit someone's potential based on their gender. In practice, this means creating learning environments where women and men, boys and girls feel welcome and supported to explore fields like engineering, IT, construction, or any technologically based profession. It involves providing targeted support like scholarships, mentorship, and addressing biases to ensure underrepresented groups flourish. Therefore, the goal is simple: equip people with skills for success in technical and vocational careers, free from gender constraints.

**2.2 Artificial Intelligence in Education (AIED):** Artificial Intelligence, AI for short, is a technology that enables machines, specifically computer programs, to learn, think, and act for themselves. This means that AI has the ability to take in large amounts of data, process it, and make decisions very much like a human could, but much, much faster. AI is a broad and deep field of study. The term "AI" is not reserved for the kind of learning that goes on in a computer when a program is being written or perfected. That's better known as "machine learning". Instead, it refers to technology where there is some element of decision making, for example using complex math and logic, by neural networks or by a human method such as inductive logic. Hence, the AIED involves the use of machine learning, data analytics, natural language processing, and intelligent tutoring systems to enhance the teaching and learning experience (Luckin et al., 2016).

Artificial Intelligence (AI) in Technical Education refers to the use of intelligent systems and algorithms to enhance learning, teaching, and training in technical fields like engineering, IT, and applied sciences. AI can personalize learning paths, automate assessments, and provide predictive analytics to improve student outcomes. In technical education, AI-powered tools can simulate real-world scenarios for practice, offer real-time feedback on projects, and help bridge skill gaps by suggesting targeted resources. For instance, AI-driven platforms can help

students learn programming by providing instant code reviews or suggesting improvements, according to the UNESCO report "AI in Higher Education" (2021), AI can make technical education more accessible and effective by adapting to individual learning styles

### **2.3 Technology Education**

Technology education is the study of technology, in which students "learn about the processes and knowledge related to technology". As a field of study, it covers the human's ability to shape and change the physical world to meet needs, by manipulating materials and tools with techniques. It also refers to the study and application of technological systems, tools, and processes, preparing individuals for careers in technical and vocational sectors (International Technology and Engineering Educators Association, 2020).

### **3.0 Historical Context of Gender Inequality in Technology Education**

Historically, technical fields (STEM) have been male-dominated, with gendered stereotypes discouraging girls and women from pursuing careers in science and technology. These patterns persist in part due to societal expectations, lack of female mentors, and biased teaching practices (UNESCO, 2017). In some part of Africa for instance, only 30% of students enrolled in STEM-related courses in tertiary institutions are female (UNESCO, 2021). Factors contributing to this include early marriage, domestic responsibilities, and gender-based violence, all of which limit girls' ability to pursue long-term education.

#### **3.1 The State of Gender and Inclusion in Technology Education**

The state of gender inclusion in technology education has been a pressing concern in recent times. Despite progress, women continue to face challenges in accessing technology education. Globally, women make up only 26-28% of tech roles, with even lower representation in technical positions like software engineering (15-20%) and leadership roles (10-12%). Gender equality in technology remains limited, with women holding only about 27-30% of technical or technological roles globally and occupying only 6% of top CEO positions. Despite slow progress, women remain underrepresented in technical. For instance, women hold roughly 27.6% of jobs in the tech industry as of 2022, a figure that has seen minimal growth despite awareness. While only 6% are at the top of 100 global technology. Furthermore, for every 100 men promoted to manager in tech, only 52 women. In same vein about 44% of analysed Artificial negligence systems demonstrate gender bias further poised to amplify existing stereotypes and inequality.

In Nigeria, there exist wide variations in general education across the States and zones with the North east and North west presenting the worst scenarios in Nigeria Abdullahi Magaji et'al (2019). Recent evidence indicates that gender disparities in education and early marriage remain pronounced in Nigeria, particularly in the northern regions. Nationally, more than 18.5 million children are out of school, with girls constituting the majority (about 10 million), and in some northern areas fewer than one-fifth of girls attend secondary school (MarieClaire Nigeria, 2024). Complementary estimates suggest that about 7.6 million girls are currently out of school, with average lower-secondary attendance for girls around 48.8%, but falling sharply in states such as Sokoto (15.8%) and Katsina (27.6%) (UNICEF, 2025). Early marriage remains a major structural barrier to girls' education and empowerment: over 3.7 million Nigerian women aged 20–24 were married before age 18, and approximately one-third of young women nationally (33.4%) marry before 18, with prevalence approaching 50% in the North-East and North-West regions (UNICEF, 2025). State-level analyses further reveal the depth of the challenge, showing that among women aged 20–24, child marriage rates reach as high as 82.1% in Katsina and 76.9% in Jigawa, underscoring persistent socio-cultural constraints that limit girls' educational participation and access to opportunities in fields such

as technology and innovation (Save the Children Nigeria, 2025). Together, these statistics demonstrate that despite gradual progress, northern Nigeria continues to experience severe and systemic gender gaps in education and life opportunities for girls.

In Nigeria, efforts are being made to promote gender inclusion in tech education. The MTN Foundation and Women Innovate have joined forces to bridge the gender gap in science and technology. The 4th Women in Tech and Engineering Summit in Abuja emphasized the importance of mentorship, skills development, and targeted investments in STEM fields.

Overall, while progress has been made, there is still a need for sustained efforts to achieve gender parity in tech education. Encouraging girls and young women to pursue STEM careers can drive innovation and economic growth.

#### **4.0 Challenges and Considerations in AI-driven Gender Inclusion in Technology education**

While AI-driven technology education has the potential to promote gender and inclusion, there are challenges with gender inclusion in Technical and Vocational Education and Training (TVET) in North West Nigeria. These challenges connote faces severe constraints, primarily driven by deep-seated socio-cultural and religious norms, early marriage, and patriarchal views that marginalise women in technical fields. Key barriers include Bias in AI, limited access to education, inadequate infrastructure, insecurity, and low female enrollment in STEM and technical trades like engineering. and considerations to be addressed:

##### **4.1 Bias in AI**

The use of AI in education is not without risks. AI algorithms can perpetuate biases if not designed with inclusivity in mind. AI systems are only as unbiased as the data they are trained on, and many AI models reflect the societal inequalities embedded in historical datasets (Crawford, 2021). If not carefully designed and monitored, AI technologies may unintentionally reinforce gender stereotypes (Binns, 2018). For example, an AI system that prioritizes performance metrics without considering socio-cultural contexts may mislabel female learners as underperforming, further entrenching negative biases.

##### **4.2 Barriers to Gender Inclusion in Technology Education**

**Socio-Cultural Standards** in many cultures, societal expectations place women in traditional, non-technical roles. Societal standards and biases like believe that women are only good in domestic roles and that the need physical strength to excel in technical tasks discourage women from entering tech fields. These norms discourage female students from exploring technology-related fields (UN Women, 2019).

**Digital Divide** Women and girls in developing countries are significantly less likely to have access to digital devices and the internet. GSMA (2020) reports that women in low-income nations are 20% less likely to own smartphones.

**Gender-Biased Curricula and Teaching Methods** Educational content often includes gender stereotypes, for example teachers might encourage boys more in subjects like math and science, while offering more praise to girls for behavior and neatness rather than intellectual contributions. This and other classroom dynamics may discourage female participation. AI systems that rely on biased data may further intensify these issues (Binns, 2018).

**Limited Role Models** and the lack of visible female leaders in tech discourages girls from envisioning themselves in similar roles. Mentorship and exposure to successful women in STEM are critical.

## 5.0 Breaking Barriers with AI-Driven Technology Education

First, it's important not just to see women and girls as users of technology rather as creator of technology, promoters, and decision-makers in that field. One assumption is that the use of digital tools will increase for everyone with universal internet access. But what we see is that 76% of the population living in least developed countries are covered by mobile broadband signal, but only 25% are online. And out of those 25%, men are 52% more likely to be online than women. So, infrastructure alone is not sufficient to reach meaningful access for women. Other critical factors are affordability, digital literacy, privacy, safety, content, relevance, ownership, awareness about tools, agency, or even access to electricity.

AI-driven technology education can help break barriers in several ways among which include the undermentioned:

**Personalized Learning:** AI can tailor learning experiences to individual needs, talent and styles.

**Accessible Learning:** AI can make technology education more accessible to underrepresented groups. Connecting the many million women that still lack access to mobile networks AI tools is of paramount importance to foster a more inclusive technological education.

**Inclusive Curriculum Design:** AI can help design curricula that address the needs and interests of diverse learners.

**Initiatives to Promote Gender Inclusion:** Girls and Women with talent in Technology education can be empowered through training and advocacy.

**Bridging Gaps with AI-Driven Technology Education**

AI-driven technology education can help bridge gaps in several ways as recommended below:

### **Mentorship Programs**

AI can facilitate mentorship programs for underrepresented groups. Mentorship programs leveraging AI have the potential to revolutionize how underrepresented groups access guidance and support in tech and beyond. By harnessing AI-driven matching algorithms, these programs can connect individuals with mentors who share similar interests, goals, or backgrounds - fostering more meaningful relationships. AI breaks down geographical barriers, opening doors to a global pool of experts who might otherwise be out of reach. This is particularly empowering for those in remote or underserved areas where local mentorship opportunities are scarce. Personalized learning paths, suggested by AI, help mentees focus on skills that matter most to their growth. Whether it's coding, leadership, or navigating industry challenges, AI tailors' resources to individual needs. Scaling support is another AI advantage. With the ability to manage large numbers efficiently, more people can access mentorship without overwhelming human coordinators. For underrepresented groups, AI-driven mentorship programs offer targeted support. They can address specific challenges women, minorities, or other groups face in tech, providing a safe space to share experiences and gain advice. The key is ensuring AI systems are designed to be fair and inclusive. If done right, these programs can build bridges to opportunities, helping create a more diverse and equitable tech landscape

**Networking Opportunities:** AI can provide networking opportunities for underrepresented groups.

## **Role Models and Representation**

AI can promote role models and representation in technology education. Mentorship and community feature foster connections, allowing for shared experiences and collaboration in the form of Scholarships and financial aid, paired with AI-driven education, can remove cost barriers, thereby encouraging more gender inclusivity.

## **Infrastructure and Resources**

AI-driven technology education requires infrastructure and resources to be effective as well as to ensure gap are bridged. Investing in infrastructure and resources is crucial to making AI-driven tech education accessible to women. Robust digital platforms, high-speed internet, and AI-powered learning tools can bridge geographical gaps, allowing women from underserved areas to tap into quality education. Cloud-based labs and virtual environments enable hands-on practice without expensive hardware, leveling the playing field. Partnerships with telecoms and tech companies can provide affordable devices and data plans, tackling connectivity hurdles. Curated content, including video tutorials and interactive modules, caters to diverse learning styles. AI-driven platforms offer personalized feedback and support, helping women progress at their own pace. To succeed, initiatives must prioritize inclusivity, ensuring AI tools are accessible and content is culturally relevant. With the right infrastructure, AI-driven education can empower women, equipping them with skills to thrive in vocational technology.

## **6.0 Conclusion**

Artificial Intelligence (AI) holds significant promise in addressing and mitigating various challenges faced by women, including gender bias and discrimination. By leveraging AI algorithms, biases in recruitment processes, performance evaluations, and decision-making systems can be reduced, leading to fairer outcomes and increased opportunities for women in education, employment, and leadership roles. Furthermore, AI applications can improve women's access to quality healthcare and address gender-specific health issues. However, it is crucial to recognize and address potential challenges and risks associated with AI. Gender bias in training data and algorithmic decision-making can perpetuate existing inequalities and further marginalize women. To fully realize the potential of AI in promoting women's empowerment, it is imperative to adopt inclusive and ethical practices. This includes actively engaging women in AI development and decision-making processes. By embracing inclusive and ethical AI practices, we can harness the full potential of AI as a powerful tool for achieving gender equality and creating a more inclusive and empowered society for all. AI-driven technology education has the potential to break barriers and bridge gaps in promoting gender and inclusion around the world.

## **7.0 RECOMMENDATIONS**

In view of the conclusions from the study, the following are recommended with a view to bridging gender gaps in VTE programmes in the area:

1. AI algorithm should be used to design real time yet simple mobile videos of vocational and technical programmes geared towards solving problems of poverty, unemployment, and insecurity in the Northern area.
2. Special scholarship should be design in the area AI to female students into VTE education programmes.

3. AI induced research concept should be thought to women starting from the adolescence age to facilitate real time innovations which would in turn boost women contribution to technology.
4. Government AI algorithms should be leveraged and designed to facilitate recruitment processes that favors women.
5. Harmful institutional practices which are anti female should be campaigned against using AI tool designed in indigenous languages.

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# Africanising Research Methods in Construction Technology for Sustainable Economic Growth and Entrepreneurial Empowerment

**P. Tachia Nambeh**

Department of Industrial Technology  
Father Adasu University, Makurdi.  
[ntachia@bsum.edu.ng](mailto:ntachia@bsum.edu.ng)

## ABSTRACT

*The overreliance on Eurocentric research paradigms in Africa's construction technology sector often neglects indigenous knowledge systems, thereby limiting the relevance and sustainability of solutions. This paper proposes the Africanisation of research methods in construction technology as a vital step towards ensuring sustainable economic growth and entrepreneurial empowerment in Africa. The paper defines Africanisation as the process of ensuring that research methodologies and approaches in the construction technology sector are informed and adapted to African epistemology and values. Through an integrative literature review and conceptual analysis of research approaches in construction technology, this paper explores the theoretical foundations of Africanisation and decoloniality. The paper also explores the links among indigenous knowledge, sustainable construction technology, and entrepreneurial empowerment. The paper concludes by proposing a framework for Africanising research approaches in construction technology. The paper concludes that Africanisation of research approaches in construction technology could be a vital step towards ensuring sustainable economic growth and entrepreneurial empowerment in Africa. This is because Africanisation of research approaches in construction technology could lead to the development of more appropriate and adoptable technologies in the sector. This could, in turn, lead to entrepreneurial empowerment in the sector. The paper concludes that the Africanisation of research approaches in construction technology could be a vital step towards ensuring sustainable economic growth and entrepreneurial empowerment in Africa.*

**KEYWORDS:** Africanisation, Construction Technology, Entrepreneurial Empowerment, Indigenous Knowledge Systems, Research Methods, Sustainable Economic Growth

## 1. Introduction

The construction industry in Africa is a major driver of economic development, employment creation, and infrastructure development (Udo & Agbai, 2023). Nonetheless, it is also a major challenge to address, given issues of high carbon footprint, inefficient use of natural resources, and a high dependence on imported technologies that often do not take local needs into account (Lugya, 2025). In parallel, the construction technology development methodologies that guide research in Africa have been primarily based on Western epistemology, which has been criticized for ignoring local knowledge systems (Keikelame, 2019). This situation calls for a pressing need to "Africanise" research methodologies, i.e., to develop new methodologies that are closely aligned to African philosophies, societies, and environments (Letsekha, 2024). This is not an exercise in isolationism; it is a deliberate approach to ensure that construction technologies developed in Africa are locally relevant, sustainable, and owned (Letsekha, 2024). This paper argues that "Africanising" construction technology development

methodologies can be a major driver in achieving the twin objectives of promoting sustainable economic development and empowering local entrepreneurs (Udo & Agbai, 2023). This paper examines this assertion, including a conceptual basis, a review of relevant literature, and a pathway for transformation.

## **2. Statement of the Problem**

The construction industry in Africa is at a crossroads, with tremendous opportunities for growth and development, but equally high risks of adopting unsustainable global practices that have contributed to environmental degradation, high costs, and lack of value addition (Lugya, 2025). A major underlying factor for this phenomenon is the epistemology of the research that informs this industry. In particular, mainstream construction research methodologies adopted in Africa seem to favor quantitative, positivist approaches that may not adequately account for socio-cultural issues, resource endowments, or indigenous problem-solving strategies (Malapane et al., 2024). This "foreignization" of research methodologies leads to a knowledge gap, in which technically sound solutions are socially inappropriate or economically unaffordable. This has resulted in a lack of locally developed construction technologies to support innovation, entrepreneurship, and the growth of indigenous construction small and medium-sized enterprises, which lack the necessary knowledge base to compete effectively (ILO, 2025). In this context, the problem is therefore twofold: (1) the dominance of decontextualized research methodologies that do not tap into African ingenuity, and (2) the failure to leverage this as a major driver for sustainable economic development and entrepreneurial empowerment through the construction industry.

## **3. Aims and Objectives**

This paper presents a case for a new approach to Africanizing construction research methodologies in construction technology to support sustainable economic development and the empowerment of entrepreneurship in Africa.

Specifically, the objectives are:

- i. To explain the concepts of "Africanisation" and "Africanised research methods" in the framework of construction technology.
- ii. To explore the theoretical and ethical foundations of decolonial and indigenous research methodologies pertinent to the African continent.
- iii. To survey literature pertaining to the interrelationship between indigenous knowledge systems, sustainable construction, and entrepreneurial development in Africa.
- iv. To develop a conceptual framework for "Africanising" research methodologies pertinent to construction technology.
- v. To offer suggestions for researchers, educators, policymakers, and industry practitioners to operationalise "Africanised" research methodologies.

## **4. Theoretical Basis**

The rationale for "Africanising" research methodologies is based on two interrelated theoretical bodies of knowledge: decolonial theory and indigenous knowledge systems.

Decolonial theory challenges the epistemology of knowledge production rooted in Western epistemology. It asserts that the coloniality of power and knowledge persists long after

political independence. It determines what qualifies as valid knowledge, including research (Letsekha, 2024; Keikelame, 2019). "Decolonising" research methodologies entails "centering" the concerns, epistemologies, and voices of marginalised communities, thereby reclaiming the right to self-representation and self-definition of problems (Chigevenga, 2022). In the case of construction technology, it entails going beyond mere data collection in Africa to knowledge production from and for Africa, asking questions pertinent to local problems, including housing, climate change, and the use of local materials.

Indigenous Knowledge Systems (IKS) are defined as knowledge that is cumulative, dynamic, and location-specific, developed over centuries of interaction with the environment (Malapane et al., 2024). IKS is not stagnant folklore; it is valid, systematic knowledge used for resource management, design, and construction. IKS theories propose that IKS is comprehensive, relational, and may be communicated through oral or experiential learning. Incorporating IKS into construction research will legitimize local knowledge, potentially lead to more environmentally friendly and culturally sensitive construction (for example, natural cooling and processing of local materials), and lay the groundwork for community-driven innovation and entrepreneurship.

These theories converge to support Africanisation as a process of epistemic inclusion, where research is a collaborative, context-embedded process for the purposes of liberation and sustainable development.

## **5. Conceptual Clarification**

**Africanisation:** In this paper, Africanisation is the intentional and critical process of adapting, modifying, and creating research methodologies that are informed by, responsive to, and reflective of African realities, philosophies (e.g., Ubuntu, Ayatutu; which espouse the philosophy of 'I am because you are, therefore we are'), histories, and aspirations. This is not about negating global science but about critically engaging with it in a dialogue from an African perspective and agency (Udo & Agbai, 2023).

**Africanised Research Methods:** These refer to research methodologies that may involve, for instance, the application of Participatory Action Research with communities as co-researchers, narrative research, ethnography to study local practices, and the validation of findings through the communities themselves. These research methods are chosen for their appropriateness to African communicative traditions and societal structures.

**Construction Technology:** The application of techniques, tools, materials, processes, and knowledge in the design, construction, and maintenance of the built environment. In the context of Africanisation, it is the indigenous and hybridised technologies.

**Sustainable Economic Growth:** Economic development that meets the present needs without compromising the ability of the future to meet its needs in the present, through the application of resource-efficient, context-specific, and context-driven construction activities that generate employment opportunities and stimulate related industries.

**Entrepreneurial Empowerment:** The process of enhancing the capabilities, opportunities, and agency of individuals and SMEs in the construction industry. This includes access to knowledge, skills, finance, and markets, enabling individuals and SMEs to innovate, compete, and grow in the industry (ILO, 2025).

## **6. Literature Review**

### **6.1. Africanisation, Decoloniality, and Research**

The Africanisation of knowledge production is an important theme in the discussions in the field of higher education and the social sciences. Letsekha (2024) argues that Africanisation and decoloniality can be used to achieve the goal of relevance and equity in education. This means that, in research, methodologies should not be Eurocentric. Rather, they should be such that they share power in the research process, such that the communities benefit from the knowledge produced (Keikelame, 2019). This is in line with the new wave of research in the context of Sub-Saharan African countries, where the importance of Indigenous Methodologies is gaining prominence, where the research should be answerable to the community (Chigevenga, 2022).

## **6.2. Indigenous Knowledge and Sustainable Construction**

Research has shown that IKS is important for the sustainability of the construction industry. Malapane et al. (2024) highlight the challenges facing IKS but also its importance for the sustainability of the communities that use it. This knowledge, in the context of the construction industry, includes how to use adobe, thatch, and laterite, which have low embodied energy and are also climatically appropriate (UNEP, 2024). Research has also shown that the drivers of sustainable construction in Sub-Saharan African countries, such as that by Lugya (2025) in Uganda, highlight that reducing the use of natural resources is a key driver, a principle inherent in indigenous knowledge.

## **6.3. Entrepreneurship and Empowerment in Construction**

The construction industry is an important area for SME development. Yet, SMEs are constrained by limited access to technology and skills. The effectiveness of empowerment strategies, such as ILO-sponsored training in South Africa's Waterberg District, has proven that business development support can significantly improve the productivity and sustainability of construction SMMEs. Such strategies are more likely to be effective if the technical content—the "what" being taught—is itself informed by research that is pertinent to Africa. The pertinent research is what constitutes Africanised research.

## **6.4. The Innovation Driver Nexus**

Innovation is essential for sustainable construction. Client demands and project performance are important drivers of innovation, as proposed by Van Nguyen et al. (2023). In an Africanised framework, client demands encompass communities and local governments, while performance encompasses socio-cultural acceptability and economic inclusivity. Therefore, Africanised research, which articulates client demands relevant to Africa, has the potential to become an important driver of innovation in Africa's construction industry.

## **7. Methodology and Research Method**

The research design used for this paper is qualitative conceptual research with an integrative literature review. The research objective is to create new knowledge through an integrative literature review. The research draws on diverse literature from disciplines including decolonial theory, indigenous knowledge, construction management, and entrepreneurship. The research method used is as follows:

**Systematic Searching:** The researcher used Google Scholar and Scopus to search for literature on keywords such as "Africanising research," "decolonial research methodology," "indigenous knowledge construction Africa," "sustainable construction Africa," "construction SME empowerment," etc. The literature reviewed is from the last ten years (2015-2025).

**Critical Analysis:** Thematic analysis of the texts was used to understand the underlying arguments and concepts related to the research paper's focus.

Conceptual Synthesis: The information gleaned from the texts was synthesized to create a better understanding of the concepts and a framework for the argument on the importance of Africanising research methods.

The approach is also a reflection of the research paper's thesis, in that it prioritises and synthesises voices and research from and on the African context.

## **8. Result Presentation and Discussion**

The result of the integrative review is the identification of key findings that form the pillars of the proposed framework for Africanising research in construction technology.

### **8.1. Pillars of an Africanised Research Framework**

Epistemic Pluralism: Research must create space for multiple forms of knowing and value both scientific and indigenous knowledge. This is achieved through research methods such as participatory mapping, interviews with elders, and apprenticeships.

Community as Co-Researchers: Research must move from the use of the term "subjects" to the term "participants" and involve the community in the research through the formulation of the research problem, research design, data collection, and data analysis.

Context-Embedded Problem Formulation: Research must begin with identifying a research problem from the community through dialogue on pressing needs, such as flood-resilient building techniques or affordable housing technologies using local resources.

Ethics of Care and Benefit: The research must be guided by an ethic of Ubuntu, which ensures that the community from which it is drawn benefits in a tangible way.

Translation for Enterprise Development: The research results need to be translated into forms that are easily understood by entrepreneurs, such as simplified technical manuals, business case studies, and prototype designs.

### **8.2. Discussion: Linking Methodology to Growth and Empowerment**

The Africanising research methods directly respond to the problem statement. By starting with local knowledge and needs (Pillars 1 & 3), research is more likely to generate viable, feasible, and acceptable technological solutions that can be sustained in the long term. For example, research conducted in collaboration with the community to improve the durability of compressed earth blocks using local stabilisers can lead to viable SME business opportunities in the manufacture of bricks.

The process of participation in research (Pillar 2) is also empowering, promoting research and critical-thinking skills in communities. This promotes a culture of innovation from the grassroots level. Furthermore, by engaging with local knowledge and skills (a direct outcome of epistemic pluralism), research can help to reduce the need for external inputs, retain the benefits within the local economy, and generate markets for small-scale suppliers and makers. This is by focusing on the inherent and intrinsic properties of African indigenous materials and technologies that can be upgraded, and the products applied to solving problems, for which currently imported, expensive, and most times incongruent solutions are used.

Lastly, the Africanising research methods also ensure that the knowledge generated is not confined to research journals but can be used to empower entrepreneurship (Pillar 5). Training packages for SMMEs, such as the ILO model (ILO, 2025), can be enhanced with content

developed through such research, making the empowerment process more effective and sustainable.

## **9. Conclusion and Recommendations**

The paper has provided sufficient evidence to prove that the Africanising research methods in the construction technology field is a viable and unexplored opportunity for promoting sustainable economic growth and entrepreneurial empowerment in the African context. By engaging with decolonial ethics and indigenous knowledge systems, the construction technology field can generate innovations that are technically viable, socially acceptable, and economically inclusive, thereby turning local challenges into opportunities for innovation and enterprise development.

### **Recommendations:**

i. For Researchers and Academics:

Develop and test Africanised methodological frameworks in construction research studies. Focus on participatory approaches and partnerships with community knowledge holders.

ii. For Higher Education Institutions (HEIs):

Revise the construction technology and research methodologies curriculum to include courses on decolonial theories, indigenous knowledge systems, and participatory approaches.

iii. For Policymakers:

Develop a national-level research and innovation policy that supports and funds context-driven, community-engaged research studies in the built environment. Include indicators of local relevance and SME linkage when assessing research grant applications.

iv. For Industry and Professional Bodies:

Collaborate with HEIs and communities in conducting applied research studies. Develop certification and training programs for construction SMEs based on locally validated and Africanised research studies.

v. For Development Partners:

Support tripartite partnerships among academia, communities, and industry to develop context-appropriate construction technologies and business models.

The process of developing Africanised research methodologies is an essential step in taking back the reins of the development process in Africa. It is through such epistemologically and socially accountable research that the built environment sector will be able to create a sustainable and empowered future for the continent.

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# Effect of Multimedia Instructional Strategies on Secondary School Students' Academic Achievement and Retention in Basic Science and Technology in Makurdi LGA, Benue State

Uduaka, Anieze, Ph.D<sup>1</sup>, & Akighirga, Aluemo Benedicta<sup>2</sup>

<sup>1&2</sup> Department of Integrated Science Education, Joseph Sarwuan Tarka University, Makurdi  
[uanieze@gmail.com](mailto:uanieze@gmail.com)<sup>1</sup>, [benedictaaluemo@gmail.com](mailto:benedictaaluemo@gmail.com)<sup>2</sup>

## ABSTRACT

*The study investigated the effect of multimedia instructional strategies on secondary school students' academic achievement and retention in Basic Science and Technology in Makurdi LGA. Four research questions were asked and answered and four hypotheses were tested at 0.05 level of significance. A pre-test post-test quasi-experimental research design was adopted for the study. The population of the study was 7,834 upper basic two students. Simple random sampling techniques was used to sample 84 (46 Male and 38 Female) students in two intact classes from the population. Basic Science and Technology Achievement Test (BSTAT) and Basic Science and Technology Retention Test (BSTRT) were used as instrument for data collection. A reliability coefficient of 0.88 was obtained using, kuder-Richardson 20 formula. Data were analyzed using mean and standard deviation, to answer research questions while the null hypotheses were tested using analysis of Covariance (ANCOVA). Findings of the study showed that there is a statistically significant difference between the mean achievement and retention scores of students taught Basic Science and Technology with multimedia instructional strategy and those taught using lecture method amongst others. Based on the results of the findings, the researcher concludes that the method employed in teaching Basic Science and Technology has significant effects on students' achievement and retention. Students significantly achieve higher and retained more when taught using multimedia instructional strategy. Therefore, it was recommended amongst others that Basic Science and Technology teachers should endeavour to use multimedia in the teaching of Basic Science and Technology, especially in secondary schools.*

KEYWORDS: Multimedia, Achievement, Retention, Basic Science and Technology, and Secondary School Students.

## INTRODUCTION

Science and technology have always been recognized as critical factors in the process of development. Through its application, the resources of nations have been transformed into goods and services all over the world. Abdulkadir (2011) remarked that the current development in science and technology has greatly affected the lives of every human being such that, to be ignorant of the basic knowledge of this development is to live an empty, meaningless and probably unrealistic life. For any nation to attain the status of self-reliance, science must be an important component of that nation irrespective of race, creed or sex. Science can be defined as the systematic body of knowledge obtained by methods or techniques based on observation and experimentation as its authority. It seeks to explain the

natural phenomenon using enquiry processes or activities. The branches of science that makes up Basic Science and Technology are: Biology, Physics, Chemistry, among others.

Basic Science and Technology is a core subject at the Junior Secondary School (JSS) level in Nigeria, introduced to lay the foundation for scientific knowledge and stimulate students' interest in science-related disciplines. The Nigerian Educational Research and Development Council (NERDC, 2007) emphasizes that the Integrated Science curriculum is intended to develop students' skills in observation, experimentation, and critical thinking, thereby preparing them for further studies in science and technology. However, evidence suggests that students' achievement and retention in Basic Science and Technology remain low, especially in public secondary schools across Benue State (Agbo-Egwu, 2010; Okebukola, 2012). Conventional instructional strategies commonly used in classrooms, such as the lecture method, have been criticized for being teacher-centered and ineffective in stimulating students' interest and active participation (Obeka, 2011). These methods often fail to cater to diverse learning styles and do not provide students with the opportunity to interact meaningfully with the content. According to Ezeudu (2013), the lack of effective, engaging, and learner-centered approaches contributes significantly to poor achievement and low retention rates in science subjects.

Academic achievement of Upper Basic Schools students is an important factor affecting the achievement of higher education goals (Zhu, 2016). Academic achievement is a direct manifestation of learning effectiveness and a valid indicator to evaluate the effectiveness of teaching. Achievement refers to the completion and attainment of a certain level that a student can achieve after a series of education or training (Lamas, 2015). It is the result obtained through study which represents performance outcomes that indicate the extent to which a student has accomplished specific goals that were the focus of activities in instructional environments, specifically in school, college, and university (Cai & Cao, in Zheng & Mustapha, 2022). To address the poor achievement of students, efforts have been made by science education scholars towards making Basic Science and Technology simple. This has not yielded the desired result, (Ityobee, *et. al.*, 2024). The poor academic achievement of male and female students is linked primarily to the fact that the concepts taught are not retained by learners (Jackman & Morrain-Webb, 2019).

Retention is the ability to store what has been learnt and recall what has been stored in the memory, Olarewaju, (2017). The nature of the material to be coded contributes to the level of retention. Instructional strategies contribute to quality and level of retention in terms of concreteness, Ugwu *et,al*, (2020). Retention could be explained as the process or ability to retain and remember things and experiences learned by an individual at a later time. Students' retention of lesson content is a function of student ability to properly conceptualize what is learnt or being taught. The use of multimedia technologies in the classroom have been shown in a number of studies to impact positively on the students' retention, (Nwanze, *et,al.*, 2021). This is because students' can hardly forget lesson contents that involve many of their senses when various multimedia formats are used as against when conventional teaching method such as lecture method is employed.

Gender is another factor that could influence students' achievement and retention in a subject. It is a variable that has so much effect on both teachers and students in the teaching and learning processes (Ityobee, *et. al.*, 2024). Gender differences in academic achievement have been of great concern to researchers and education policy makers, both at local and international levels. It is one of the current academic issues under deliberations all over the world (Abdu-Raheem, 2012). Today, equality between boys and girls has become a major scourge plaguing the world, particularly in developing countries and also in sciences. In society today, girls are looked at as second-class citizens, which does not help nurture their careers

in sciences (Abdu-Raheem, 2012). These issues have been challenges in the educational sector.

In response to this educational challenge, multimedia instructional strategies have emerged as a promising alternative. Njoku in Akoja and Ali (2012) stated that multi-media instructional strategies are those channels of communication which promote the effectiveness of instruction and help the teacher to communicate ideas effectively to his students. Multi-media instructions are those alternative channels of communication which a Basic Science and Technology teacher can use to concretize a concept during his/her teaching. Multi-media instructional strategies include all the materials and substantial resources that an educator might use to implement instruction which facilitates students' achievement and retention of knowledge. It involves the use of text, graphics, audio, video, and animation in an integrated manner to enhance learning experiences (Ayoade, 2015). It appeals to multiple senses and provides interactive learning environments that encourage active learner engagement, thereby improving understanding and retention. Studies by Okwo and Ike (2015) and Omoifo (2012) have shown that multimedia instructional strategies can significantly improve students' academic achievement and facilitate long-term retention in science education.

Despite the growing body of literature on the benefits of multimedia in science education, there is a dearth of localized studies focusing on Integrated Science in Makurdi, Benue State. Yusuf and Bello (2020) note that the integration of multimedia tools in science teaching not only increases students' motivation but also enhances achievement and long-term knowledge retention. Therefore, this study seeks to investigate the effect of multimedia instructional strategies on secondary school students' achievement and retention in Basic Science and Technology in Makurdi, Benue State.

### **Objective of the Study**

The Objective of this study is to investigate the Effect of Multimedia Instructional Strategies on Secondary School Students' Academic Achievement and Retention in Basic Science and Technology in Makurdi LGA., Benue State. Specifically, the study sought to:

1. To find out the different in the mean achievement score of students taught Basic Science and Technology using multi-media instructional strategy and those taught using the traditional method;
2. To find out the difference in the mean retention score of students taught Basic Science and Technology using multi-media instructional strategy and those taught using the traditional method;
3. To find out the difference in the mean achievement score of male and female students taught Basic Science and Technology using multi-media instructional strategy and those taught using the traditional method;
4. To find out the different in the mean retention score of male and female students taught Basic Science and Technology using multi-media instructional strategy and those taught using the traditional method.

### **Research Questions.**

The following research questions were raised and answered.

1. What is the difference in the mean achievement score of students taught Basic Science and Technology using multi-media instructional strategy and those taught using the traditional method?

2. What is the difference in the mean retention score of students taught Basic Science and Technology using multi-media instructional strategy and those taught using the traditional method?
3. What is the difference in the mean achievement score of male and female students taught Basic Science and Technology using multi-media instructional strategy and those taught using the traditional method?
4. What is the difference in the mean retention score of male and female students taught Basic Science and Technology using multi-media instructional strategy and those taught using the traditional method?

## **Hypothesis**

The following hypotheses were formulated for the study and tested at 0.05 alpha level.

1. There is significant difference in the mean achievement score of students taught Basic Science and Technology using multi-media instructional strategy and those taught using the traditional method.
2. There is significant difference in the mean retention score of students taught Basic Science and Technology using multi-media instructional strategy and those taught using the traditional method.
3. There is significant difference in the mean achievement score of male and female students taught Basic Science and Technology using multi-media instructional strategy and those taught using the traditional method.
4. There is significant difference in the mean retention score of male and female students taught Basic Science and Technology using multi-media instructional strategy and those taught using the traditional method.

## **METHODOLOGY**

The researcher adopted a quasi-experimental research design of non-equivalent group for the study. Specifically, the study adopted a non-randomized pre-test, post-test control group design.

The study was carried out in Makurdi Local Government Area (LGA), Benue State. The population of the study was 7,834 upper basic two students in 55 secondary schools. The sample size for the study was 84 (46 male and 38 female) Upper Basic II (JSS2) students. The study used Basic Science and Technology Achievement Test (BSTAT) and Basic Science and Technology Retention Test (BSTRT) as instrument for data collection. The instrument was validated by two (2) experts and the reliability coefficient was established to be 0.88 using kuder-Richardson 20 formula. The data collected were analyzed using mean and standard deviation to answer the research questions and analysis of covariance (ANCOVA) to test the hypothesis.

## **RESULTS AND DISCUSSION**

### **Results**

The results of the study were presented according to research questions answered and hypotheses tested as follows:

### Research Question 1

What is the difference in the mean achievement score of students taught Basic Science and Technology using multi-media instructional strategy and those taught using the lecture method?

**Table 1: Mean and Standard Deviation Scores of Students taught Basic Science and Technology with Multi-media Instructional Strategy and those Taught using Lecture Method**

Group	N	Pre-BSTAT		Post-BSTAT		Mean Gain
		Mean	SD	Mean	SD	
Multi-media	44	21.82	2.05	29.36	3.35	<b>7.54</b>
lecture method	40	21.83	2.11	27.00	4.10	<b>5.17</b>
Mean Difference		<b>0.01</b>		<b>2.36</b>		<b>2.37</b>
<b>Total</b>	<b>84</b>					

The results presented in Table 1, shows that the mean achievement scores of students taught Basic Science and Technology multi-media instructional strategy was 21.82 for pre-test and 29.36 for the post-test with corresponding standard deviation of 2.05 and 3.35 respectively. However, the mean achievement scores of students taught Basic Science and Technology using the lecture method was 21.83 for the pre-test and 27.00 for the post-test, with standard deviation of 2.11 and 4.10 respectively. The mean gain for the multi-media group was 7.54 while the lecture method group was 5.17. The group mean difference was 0.01 for pre-test and 2.36 for post-test while the mean gain was 2.37 in favor of the multi-media group.

### Research Question 2

What is the difference in the mean retention score of students taught Basic Science and Technology using multi-media instructional strategy and those taught using the lecture method?

**Table 2: Mean and Standard Deviation of Retention Scores of Students taught Basic Science and Technology with Multi-media Instructional Strategy and those Taught using Lecture Method**

Group	N	Post-BSTAT		Retention-BSTAT		Mean Gain
		Mean	SD	Mean	SD	
Multi-media	44	29.36	3.35	30.52	2.40	<b>1.16</b>
Lecture Method	40	27.00	4.10	26.70	3.93	<b>0.30</b>
Mean Difference		<b>2.36</b>		<b>3.82</b>		<b>0.86</b>
<b>Total</b>	<b>84</b>					

The results presented in Table 2, shows that the mean retention scores of students taught Basic Science and Technology with multi-media instructional strategy was 29.36 for post-test and 30.5 for the retention test with corresponding standard deviation of 3.35 and 2.40 respectively. However, the mean retention scores of students taught Basic Science and Technology with the lecture method was 27.00 for the post test and 26.70 for the retention test, with standard deviation of 4.10 and 3.93 respectively. The mean gain for the multi-media group was 1.16 while the lecture method group was 0.30. The group mean difference was

2.36 for post-test and 3.82 for retention test while the mean gain was 0.86 in favor of the multi-media group.

### Research Question 3

What is the difference in the mean achievement score of male and female students taught Basic Science and Technology using multi-media instructional strategy and those taught using the lecture method?

**Table 3: Mean and Standard Deviation Scores of Male and Female Students taught Basic Science and Technology with Multi-media Instructional Strategy.**

Group	N	Pre-BSTAT		Post-BSTAT		Mean Gain
		Mean	SD	Mean	SD	
Male	23	21.22	2.37	28.13	3.40	<b>6.91</b>
Female	21	22.48	1.40	30.71	2.78	<b>8.23</b>
Mean Difference		<b>1.26</b>		<b>2.58</b>		<b>1.32</b>
<b>Total</b>	<b>44</b>					

The results presented in Table 3, shows that the mean achievement scores of male students taught Basic Science and Technology with multi-media instructional strategy was 21.22 for pre-test and 28.13 for the post-test with corresponding standard deviation of 2.37 and 3.40 respectively. However, the mean achievement scores of female students taught Basic Science and Technology using the multi-media instructional strategy was 22.48 for the pre-test and 30.71 for the post-test, with corresponding standard deviation of 1.40 and 2.78 respectively. The mean gain for the male students was 6.91 while the female students was 8.23. The group mean difference was 1.26 for pre-test and 2.56 for post-test while the mean gain was 1.32 in favor of the female students.

### Research Question 4

What is the difference in the mean retention score of male and female students taught Basic Science and Technology using multi-media instructional strategy and those taught using the lecture method?

**Table 4: Mean and Standard Deviation of Retention Scores of Male and Female Students taught Basic Science and Technology with Multi-media Instructional Strategy.**

Group	N	Post-BSTAT		Retention-BSTAT		Mean Gain
		Mean	SD	Mean	SD	
Male	23	28.13	3.40	29.83	2.39	<b>1.70</b>
Female	21	30.71	2.78	31.29	2.24	<b>0.58</b>
Mean Difference		<b>2.58</b>		<b>1.46</b>		<b>1.12</b>
<b>Total</b>	<b>44</b>					

The results presented in Table 4, shows that the mean retention scores of male students taught Basic Science and Technology multi-media instructional strategy was 28.13 for post-test and 29.83 for the retention test with corresponding standard deviation of 3.40 and 2.39 respectively. However, the mean retention scores of female students taught Basic Science and Technology using the multi-media instructional strategy was 30.71 for the pre-test and 31.29

for the post-test, with corresponding standard deviation of 2.78 and 2.24 respectively. The mean gain for the male students was 1.70 while the female students was 0.58. The group mean difference was 2.58 for post-test and 1.46 for retention test while the mean gain was 1.12 in favor of the male students.

### Hypothesis 1

There is significant difference in the mean achievement score of students taught Basic Science and Technology using multi-media instructional strategy and those taught using the traditional method.

**Table 5: Analysis of Covariance of Academic Achievement Scores of Students taught Basic Science and Technology using Multimedia Instructional Strategy and those taught using Lecture Method**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
<b>Corrected Model</b>	340.394 <sup>a</sup>	2	170.197	15.012	.000	<b>.270</b>
<b>Intercept</b>	88.292	1	88.292	7.788	.007	<b>.088</b>
<b>Pretest Group</b>	220.849	1	220.849	19.480	.000	<b>.194</b>
<b>Error</b>	918.308	81	11.337			
<b>Total</b>	68183.000	84				
<b>Corrected Total</b>	1258.702	83				

a. R Squared = .270 (Adjusted R Squared = .252)

The result of the Analysis of Covariance presented in Table 5 shows that the P-value of 0.002 is less than .05 ( $P < 0.05$ ) level of significance. This shows that the test was significant. Therefore, the null hypothesis was rejected. The result implies that there is a statistically significant difference between the mean achievement scores of students taught Basic Science and Technology with multimedia instructional strategy and those taught using lecture method. This means that students who were exposed to multimedia instructional strategy achieved higher than those not exposed to multimedia instructional strategy.

### Hypothesis 2

There is significant difference in the mean retention score of students taught Basic Science and Technology using multi-media instructional strategy and those taught using the traditional method.

**Table 6: Analysis of Covariance of Retention Scores of Students taught Basic Science and Technology with Multimedia Instructional Strategy and those taught with Lecture Method**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
<b>Corrected Model</b>	1009.884 <sup>a</sup>	2	504.942	276.962	.000	<b>.872</b>
<b>Intercept</b>	59.107	1	59.107	32.420	.000	<b>.286</b>
<b>Posttest</b>	703.702	1	703.702	385.982	.000	<b>.827</b>

<b>Group</b>	<b>71.761</b>	<b>1</b>	<b>71.761</b>	<b>39.361</b>	<b>.000</b>	<b>.327</b>
<b>Error</b>	147.675	81	1.823			
<b>Total</b>	70359.000	84				
<b>Corrected Total</b>	1157.560	83				

a. R Squared = .872 (Adjusted R Squared = .869)

The result of the Analysis of Covariance presented in Table 6 shows that the P-value of 0.000 is less than .05 ( $P < 0.05$ ) level of significance. This shows that the test was significant. Therefore, the null hypothesis was rejected. The result implies that there is a statistically significant difference between the mean retention scores of students taught Basic Science and Technology with multimedia instructional strategy and those taught using lecture method. This means that students who were exposed to multimedia instructional strategy retained more than those not exposed to multimedia instructional strategy.

### Hypothesis 3

There is significant difference in the mean achievement score of male and female students taught Basic Science and Technology using multi-media instructional strategy and those taught using the traditional method.

**Table 7: Analysis of Covariance of achievement Scores of Male and Female Students taught Basic Science and Technology with Multi Media Instructional Strategy and those taught with Lecture Method**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
<b>Corrected Model</b>	255.049 <sup>a</sup>	2	127.524	23.020	.000	<b>.529</b>
<b>Intercept</b>	13.734	1	13.734	2.479	.123	<b>.057</b>
<b>Pretest</b>	181.761	1	181.761	32.810	.000	<b>.445</b>
<b>Group</b>	<b>15.629</b>	<b>1</b>	<b>15.629</b>	<b>2.821</b>	<b>.101</b>	<b>.064</b>
<b>Error</b>	227.133	41	5.540			
<b>Total</b>	38420.000	44				
<b>Corrected Total</b>	482.182	43				

a. R Squared = .529 (Adjusted R Squared = .506)

The result of the Analysis of Covariance presented in Table 7 shows that the P-value of 0.101 is greater than .05 ( $P > 0.05$ ) level of significance. This shows that the test was not significant. Therefore, the null hypothesis was not rejected. The result implies that there is no statistically significant difference between the mean achievement score of male and female students taught Basic Science and Technology with multimedia instructional strategy.

### Hypothesis 4

There is significant difference in the mean retention score of male and female students taught Basic Science and Technology using multi-media instructional strategy and those taught using the traditional method.

**Table 8: Analysis of Covariance of Retention Scores of Male and Female Students taught Basic Science and Technology with Multi Media Instructional Strategy and those taught with Lecture Method**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
<b>Corrected Model</b>	155.288 <sup>a</sup>	2	77.644	33.978	.000	<b>.624</b>
<b>Intercept</b>	89.579	1	89.579	39.201	.000	<b>.489</b>
<b>posttest</b>	131.901	1	131.901	57.722	.000	<b>.585</b>
<b>Group</b>	<b>.001</b>	<b>1</b>	<b>.001</b>	<b>.000</b>	<b>.987</b>	<b>.000</b>
<b>Error</b>	93.689	41	2.285			
<b>Total</b>	41241.000	44				
<b>Corrected Total</b>	248.977	43				

a. R Squared = .624 (Adjusted R Squared = .605)

The result of the Analysis of Covariance presented in Table 8 shows that the P-value of 0.987 is greater than .05 ( $P > 0.05$ ) level of significance. This shows that the test was not significant. Therefore, the null hypothesis was not rejected. The result implies that there is no statistically significant difference between the mean retention score of male and female students taught Basic Science and Technology with multimedia instructional strategy.

## Discussion

The findings in research question and hypothesis one revealed that there is a statistically significant difference between the mean achievement scores of students taught Basic Science and Technology with multimedia instructional strategy and those taught using lecture method. The findings of this study are supported by the findings of Umar *et,al.* (2016), who found that there was significant difference in the student's achievement scores in favouring students in the experimental group. Also, the findings of the study are in agreement with the findings of Nwaze *et,al* (2018), who found that there is a significant difference between the mean achievement scores of students exposed to multimedia integrated lessons and the convectional group. The findings of the study are also in agreement with the findings of John *et,al* (2018), who found that students taught biology with multimedia instructional strategy performed better than those taught with lecture method. However, the findings of this study negate the findings of Awolaju (2016), who found that there is no significant difference between pre-test scores and post- test scores of experimental groups. This difference could be as a result of the different in the subject area and class taught.

The findings in research question two and hypothesis two revealed that there is a statistically significant difference between the mean retention scores of students taught Basic Science and Technology with multimedia instructional strategy and those taught using lecture method. This finding is supported with the findings of Nwanze *et,al* (2021), who found that the Multimedia group had a significantly higher retention score, performed better than those in the convectional group taught with modified lecture method. Again, the findings of the study are in agreement with the findings of Umar *et,al.* (2016), who found that there was significant difference in the student's retention mean scores in favouring students in the experimental group.

The findings in hypothesis three revealed that there is no statistically significant difference between the mean achievement score of male and female students taught Basic Science and Technology with multimedia instructional strategy. The finding of this study is in agreement

with findings of Enebech (2023), who found that there was no significant difference in the achievement scores of male and female students taught with educational media. Additionally, the findings of this study also agree with the findings of Awolaju (2016), who found that the post test scores of male and female students taught with multimedia instructional materials showed no significant difference between their mean scores.

The finding in hypothesis four revealed that there is no statistically significant difference between the mean retention score of male and female students taught Basic Science and Technology with multimedia instructional strategy. This finding is in agreement with the findings of Enebechi (2023), who found no significant difference in the mean retention score of male and female students taught biology with the use of educational media. Again, the findings of the study agree with the findings of Awolaju (2015), who found no significant difference in the retention of male and female students taught with multimedia instructional materials.

### **Conclusion**

Based on the results of the findings, the researcher concludes that the method employed in teaching Basic Science and Technology has significant effects on students' achievement and retention. Students significantly achieve higher and retained more when taught using multimedia instructional strategy.

### **Recommendations**

Based on the findings of the study, the following are hereby recommended:

1. Basic Science and Technology teachers should endeavour to use multimedia in the teaching of Basic Science and Technology, especially in secondary schools.
2. Multimedia instructional strategy is gender friendly and should therefore be used in teaching of Basic Science and Technology to enhance male and female students' retention in the subject.

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ERIN 2ND E-PROCEEDING

# **Influence of Big Five Personality Traits on Work Performance Among Employees of Small and Medium Scale Enterprises (SMES) In Gboko Metropolis**

**YANGE BEMGBA, PhD**  
General Studies Department  
Federal Polytechnic Wannune  
[yangebemgba@gmail.com](mailto:yangebemgba@gmail.com)

## **ABSTRACT**

The study investigated the influence of personality traits on work performance among employees of small and Medium Scale Enterprises (SMES) in Gboko metropolis. A cross sectional survey design was employed, and participants were selected using a simple random sampling technique. A total of 274 employees took part in the study, comprising 170 males and 104 females. Data were collected using the Big five personality inventory (BFI-44) and the individual work performance Questionnaire (IW PQ). Multiple regression analyses were conducted to test the research hypotheses. The findings revealed that openness to experience, conscientiousness, and extraversion significantly and independently predicted work performance. In contrast, agreeableness and neuroticism were not significant predictors. Overall, the results indicated a significant joint influence of personality traits on work performance. Based on these findings, it was recommended that SMEs in Gboko metropolis incorporate personality (psychometric) testing into the recruitment process to help identify candidates whose traits align with optimal work performance.

**KEYWORDS:** Big 5 personality, traits, work performance, Employees, SMEs

## **INTRODUCTION**

### **1.1 Background of the study**

Work performance is a central concern in organizations because it directly impacts their success. It can be defined as the transformation of efforts into productivity aimed at achieving specific results, often evaluated in terms of economy, efficiency, and effectiveness (Meyer, 2002). In the organizational context, it refers to the extent to which an employee contributes to achieving organizational goals (Rafik and Shuib, 2005). Various scholars have emphasized that performance encompasses both the goals and methods of achieving them (Ibrahim, 2004), and is often measured objectively by results achieved (Al-Edaily, 2005)

Research shows that personality traits play a significant role in determining work performance. The big five personality traits which is made up of openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism have been consistently linked to work performance across various countries and professions (Barrick & Mount, 2015; Judge, 2012; Hogan & Holland, 2013). While such relationships have been well-documented in the united states, Europe, and South Africa, particularly among employees of Small and Medium Scale

Enterprises (SMEs) in Gboko metropolis. This gap forms the motivation for the present research.

## **1.2 Statement of the problem**

The results of various studies and meta-analyses showed that Big five personality dimensions are related to work performance (Barrick & Mount; 2015; Hough, Eaton, Dunnett, Kamp & McCloy, 2009; Salgado, 2007; Tett, Jackson, Burnett & Rothstein, 2003; Vinchur, Schippmann, Sweizer & Roh, 2008). Barrick & Mount (2015) and Salgado (200) found that conscientiousness is one of the best predictors of work performances in the United States f America, Europe and South Africa. Vinchural (2008) concluded that extraversion and conscientiousness predicts work performance in various occupations in Thailand. Most of the above studies have been carried out in the United States of America, Europe, South Africa, Thailand and not among the employees of Small and Medium Scale Enterprises (SMEs) in Gboko metropolis which create and information gap. This consequently necessitated this research of influence of Big five personality traits on work performance among employees of Small and Medium Scale Enterprises (SMEs) in Gboko Metropolis to fill the vacuum.

## **1.3 Aim and objectives of the study**

The study aim to investigate the influence of Big five personality traits on work performance among employees of Small Scale and Medium Scale Enterprises (SMEs) in Gboko Metropolis to fill the vacuum.

The specific objective includes:

- i. To examine the independent and joint influence of openness to experience, conscientiousness, extraversion, agreeableness and neuroticism will influence work performance among employees of Small and Medium Scale Enterprises (SMEs) in Gboko metropolis, Benue State-Nigeria significantly.

## **1.4 Research Question**

The research question raised to guide the study is as follows:

- i. To what extent do the independent and joint influence of openness to experience, conscientiousness, extraversion, agreeableness and neuroticism will influence work performance among employees of Small and Medium Enterprises (SMEs) in Gboko metropolis significantly.

## **2.1 Conceptual Review**

### **2.1.1 Big five personality traits**

Personality traits are enduring characteristics or qualities that influence a person's behavior across different situations.

The big five personality traits are the most widely accepted model of personality. The big five personality traits are:

#### **a. agreeableness**

Agreeableness represents the tendency to be kind, cooperative, polite and gentle (Bono & Judge, 2024). Traits of agreeableness include sympathy, kindness, flexibility, trust, apology, good heartedness and tolerance (Barrick, Mitchel & Stewart, 2003). people with a high tendency to be agreeable are very popular (Wewellyn & Wislson, 2003). such people are friendly and helpful and appreciate getting along with others (Williamson, 2017).

### **b. Neuroticism**

Neuroticism is typically defined as the tendency to experience frequent and intense negative emotions in response to various sources of stress (Barlow, Saver-Zarala, Carl, Bullis & Ellard, 2014). The term refers to the phenomenon of experiencing unpleasant emotions. Neurotic traits that are very common in the public are anxiety, depression, anger, irritability, sadness, worry, and danger (Barlow et al, 2014).

Neurotics respond poorly to environmental stress, feel threatened and may experience small frustrations as hopelessly overwhelming (Widger & Oltmeanns, 2017).

### **c. Conscientiousness**

Individuals who are highly conscientious are fussy, dainty, difficult and punctual in their daily affairs. Foulkrod et al (2010) include characteristics such as organized and goal-oriented in the category of conscientiousness. Barrick, Mount and Judge (2001) believe that individuals who exhibit high levels of conscientiousness work correspondingly hard, are disciplined, and have a high performance goal.

### **d. Openness to Experience**

Individuals with these personality traits are liberal minded, concerned with the subject matter and open-minded and experienced. Brainstorming is also a characteristic of openness (Nadkarni & Hermann, 2010). Openness indicates that a person is mature and practical rather than theoretical and that he or she seeks new ideas. Such individuals are efficient in their abilities (Douglas, 2012).

### **e. Extraversion**

Extraversion is typically defined as the tendency to experience and display positive affect, assertive behavior, decisive thinking and a desire for social attention (Wilt & Pevele, 2017). Sociability of extraversion (Judge et al, 2002; Nadkarni & Hermann 2010). Individuals high in extraversion are fearlessly dominant and bold, excitement-seeking and inter-personally dominant (Carter, Miller & Widgier, 2012).

## **2.2 Work performance**

Work performance is a major concern in every organization. It is a major concern because; the success of an organization depends on work performance. Hence, work performance has emerged as an important variable in organization research and has drawn the attention of industrial organizational psychologists and management scientists over the years.

Work performance can be defined as the conversion of efforts into productivity(s) results. In the organization context, work performance refers to the extent to which an employee contributes to achieving organizational goals (Rafik and Shuib, 2005).

## **2.3 Empirical review**

### **2.3.1 Conscientiousness and work performance**

Costa and McCrae (1992) believe that individuals who are highly conscientious are fussy, dainty, difficult and punctual in their daily affairs. Foulkrod et al (2010) include characteristics such as organized and goal-oriented in the category of conscientiousness. Barrick, Mount and Judge (2001) believe that individuals who exhibit high levels of conscientiousness work correspondingly hard, are disciplined, and have a high-performance goal.

### **2.3.2 Extraversion and work performance**

Extraverts are expressive, outgoing, sociable, confident and energetic individuals who thrive on communication, enthusiasm, and social recognition. They seek admiration, control and emotional connections, making them well-suited for roles requiring frequent interaction, such

as sales, administration and social relations. Their ability to experience positive emotions contributes to job satisfaction and a generally contented personality, which supports strong job performance and emotional commitment.

### **2.3.3 Neuroticism and work performance**

Neuroticism is typically defined as the tendency to experience frequent and intense negative emotions in response to various sources of stress (Barlour, saver-Zarala, Carl, Bullis & Allard, 2004). The term refers to the phenomenon of experiencing unpleasant emotions. Neurotic traits that are very common in the public are anxiety, depression, anger, Irritability, sadness, worry and danger (Barlow et al; 2014). Neurotics response poorly to environmental stress, feel threatened and may experience small frustrations as hopelessly overwhelming (Widiger perceive the world as a dangerous and threatening place and believe they are unable to cope with or manage challenging events (Barlow, et al, 2014). Individuals who fall under the neurotic personality are easily prone to mood swings, emotional instability, over excitement (Liewellyn & Wilson, 2003), and overconfidence (Weijen, 2010). Individuals whose emotional stability is low are moody, distressed, and lonely (Raab, Stedham & Neuner, 2005) and also hostile (Fourkrod et al; 2010). According to Barrick et al (2003), people with low emotions or neurotic are tense and stressed and would prefer stress free jobs.

### **2.3.4 Agreeableness and work performance**

Agreeableness represents the tendency to be kind, cooperative, polite, and gentle, (Bono & Judge, 2004). Traits of agreeable include sympathy, kindness, flexibility, trust, good humour, apology, good heartedness and tolerance (Barrick, Mitchell & Stewart, 2003). People with a high tendency to be agreeable are very popular (Liewellyn & Wilson, 2003). Such people are friendly and helpful and appreciate getting along with others (Williamson, 2017). However, Barrick and Mount (2005) found that, agreeableness personality trait in correlation with job performance and job satisfaction is weak.

### **2.3.5 Openness to Experience Work Performance**

Openness does not consistently predict overall work outcomes but influences performance under certain conditions. It is linked to skill acquisition (oakes et al., 2001), training proficiency (Barrick & mount, 2015), and better performance in unfamiliar environments (Bing & Lounsbury, 2006). Individuals high in openness are often preferred for complex, higher-level roles due to their ambition and achievement orientation (De jong, veide & Jansen, 2001) and tend to emerge as leaders by initiating ideas and sharing opinions (kickul & Newman, 2000). Openness can enhance job efficiency by fostering curiosity, exploration, and adaptive work methods that improve productivity and effectiveness.

## **2.4 Hypothesis**

The following hypothesis has been tested in this study:

- i. Openness to experience, conscientiousness, extraversion, agreeableness and neuroticism will independently and jointly influence work performance among employees of small and medium scale enterprises (SMEs) in Gboko metropolis.

## **3.1 Method**

### **3.1.1 Design**

This study employed a cross sectional survey design. This method is the most suitable. For this research because it allows the research to sample a large number of participants. Collect

data from them through questionnaire and make inference about their level of Work performance and how is influenced by personality traits.

### 3.1.2 Setting

The study was carried out in small and medium scale enterprises in Gboko metropolis. Available records from BIRS Gboko Branch office shows that there are 110 registered SMEs in Gboko with 950 staff. However, emphasize is placed on employees,

### 3.1.4 Sample Size Determination

The sample size for this study was determined by drawing from the population of small and medium scale enterprises and thereafter, drawing from the population of employees of the sampled small and medium scale enterprise. The available records from BIRS-Gboko branch office shows that, there are 110 registered SMEs and 950. Thus, by using the sample size estimation table for known sample size for populations by Krejcie and Morgan (1970) a sample of 86 registered SMEs were randomly selected from the sampled 110 SMEs. Thereafter, the sample size for the study is 274 Employees of SMEs in Gboko metropolis.

### 3.1.5 Instruments

The instrument for this study is the questionnaire which consisted of two different scales. The questionnaire include: the 44 item version of the big five inventory (BFI-44) by John, Donahue and Kentle (1991), and individual work performance questionnaire (1spq) by Lina Koopman (2014).

## 3.2 Data Analysis

The standard multiple regression analysis was used to test the hypothesis.

## 4.1 Results

**Table 1:** Correlation Matrix for the Relationship among Openness to Experience, Extraversion, Neuroticism and Work Performance.

Table	1	2	3	4	5	6	Mean	SD
Openness	-						20.05	2.89
Conscientiousness	.056	-					19.09	2.42
Extraversion	.215**	.416**	-				18.40	2.90
Agreeableness	.050	.033	.019	-			14.13	.99
Neuroticism	.401**	.035	.170**	.166**	-		28.69	5.34
Work performance	.029	.524**	.351**	.140*	.312*	-	28.67	5.34

\*\*Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.01 level (2-tailed).

The result in Table 1 revealed that openness to experience is positively related to extraversion ( $r=.215$ ,  $p<0.01$ ), and neuroticism ( $r=.401$ ,  $p<0.01$ ). In the same vein, conscientiousness is positively related to extraversion ( $r=.416$ ,  $p<0.01$ ) and work performance ( $r=.524$ ,  $p<0.01$ ). Similarly, agreeableness is positively related to neuroticism ( $r=.170$ ,  $p<0.01$ ) and work

performance ( $r=.351$ ,  $p<0.01$ ). Furthermore, there is a positive relationship between neuroticism related work performance ( $r=.312$ ,  $p<0.01$ ).

## 4.2 Hypothesis

The hypothesis for this research is stated a significantly. This hypothesis was tested using multiple regression analysis and the result is presented below in table 2.

**Table 2:** Summary of Multiple Liner Regression Showing the Influence of Personality Traits (openness to experience, conscientiousness, extraversion, agreeableness, neuroticism) on Work Performance among Employees of SMEs in Gboko metropolis.

DV	Predictors	R	R <sup>2</sup>	F	df	$\beta$	t	P
Work performance	Constant	.762	.452	82.857	5,265		6.743	.000
	Openness					.117	2.265	.024
	Conscientiousness		.468	9.164	.000			
	Extraversion					.205	3.916	.000
	Agreeableness					.100	2.143	.033
	Neuroticism					-.395	-7.746	.000

The result in Table 2 indicated that there is a significant influence of personality traits (openness to experience, conscientiousness, extraversion, agreeableness, neuroticism) on work performance among employees of SMEs in Gboko metropolis  $R= .762$ ,  $R^2 = .452$  [ $F(2,265) =82.857$ ;  $P<0.01$ ]. Observation further shows that personality traits jointly accounted for 45.2% of the variance in work performance among employees of SMEs in Gboko metropolis. Individually, openness to experience ( $\beta = .117$ ;  $t=2.265$ ,  $p<0.01$ ), consciousness ( $\beta = .468$ ;  $t=9.164$ ,  $p<0.01$ ), extraversion ( $\beta =.205$ ;  $t=3.916$ ,  $p<0.01$ ), and agreeableness ( $\beta = .100$ ;  $t=2.143$ ,  $p<0.01$ ) significantly and positively influenced work performance, implying that employees who are high on these personality traits are likely to be high of work performance, while and neuroticism ( $\beta = -.395$ ;  $t=-7.746$ ,  $p<0.01$ ), significantly and negatively contributed the model, implying that employees who are high on neuroticism would tend to have low work performance. Furthermore, the result had revealed that conscientiousness 46.8% had the highest contribution to work performance while agreeableness 10.% made the least contribution to work performance.

## 5.1 Discussion of findings

The study aims to identify the influence of big five personality traits on work performance among employees of SMEs in Gboko metropolis. While the hypothesis stated that personality traits (openness to experience, conscientiousness, extraversion, agreeableness, neuroticism) will independently and jointly influence work performance among employees of SMEs in Gboko metropolis. Using multiple regression analysis, Observation shows that personality traits jointly accounted for 45.2% of the variance in work performance among employees of SMEs in Gboko metropolis.

Individually, openness to experience ( $\beta = .117$ ;  $t=2.265$ ,  $p<0.01$ ), consciousness ( $\beta = .468$ ;  $t=9.164$ ,  $p<0.01$ ), extraversion ( $\beta =.205$ ;  $t=3.916$ ,  $p<0.01$ ), and agreeableness ( $\beta = .100$ ;  $t=2.143$ ,  $p<0.01$ ) significantly and positively influenced work performance, implying that

employees who are high on these personality traits are likely to be high of work performance, while neuroticism ( $\beta = -.395$ ;  $t=-7.746$ ,  $p<0.01$ ), significantly and negatively contributed the model, implying that employees who are high on neuroticism would tend to have low work performance. Furthermore, the result had revealed that conscientiousness 46.8% had the highest contribution to work performance while agreeableness 10.% made the least contribution to work performance.

In a similar manner, research finding demonstrated support respectively on these personality traits (Erdheim, wang & Zicker, 2006). Sackett, (2008) found sales executives having high extraversion and generally showing good performance of social contacts, and introverted sales executive is observed to be non-suitable as compared to an extravert. Extraverts are capable of practicing affirmative emotions (Costa & Mcrae, 1997) which in turn lead to job gratification (Connolly & Visavesvare, 2000). Extraverts' individuals are emotionally firm and sure that's why they possess contented personality (Deveve & Cooper, 1998) and this is the key feature of contented life and job satisfaction (Judge et al, 2002). Extraverts are also effective analyst of job performance for professions like administrations, social relations and sales (Barrick & Mount, 2015).

The natural ability to thrive in higher complexity would mean that open individuals would be preferred for higher positions in the hierarchy. This is supplemented by the correspondence of openness to ambition and need for achievement (De jong, Velde & Jansen, 2001). Open individuals also show a natural aptitude to emerge as leaders in a group since they are most likely to initiate new ideas, ask more questions and give more opinions (Kickul & Newman, 2000). Therefore, in addition to prediction performance, openness is also important in predicting career progress.

Much has been made of conscientiousness as a predictor of work performance. Barrack and Mount (2015) well-cited findings show an uncorrected mean correlation of .15 with subject five ratings of performance. The consistency of conscientiousness validates across occupational groups prompted the researchers to single out conscientiousness as the one big five dimension that is good in all jobs.

On the other hand, agreeableness and neuroticism did not significantly and independently predict work performance among employees of SMEs. This is also inline with (Magnus et al, 2003). That neuroticism found to be negatively related with job satisfaction (Judge et al, 2002) and job performance (Barrick & Mount, 2015). According to Barrick and Mount (2015), extremely neurotic persons are incapable to work successfully on their own and resultantly, there is a less chance of including them in the labour force.

Lastly, personality psychologists posit that agreeableness is the utmost divisive personality trait of the Big five model of personality (McCrae & costa, 1997). Between agreeableness and job performance, the correlation is very weak (Barrick & Mount, 2015) and similar in the case with the relationship between agreeableness and job satisfactions (Judge et al, 2002).

## **Conclusion**

The conclusion drawn from this study is based on the findings of this research work. The researcher found that personality traits jointly predicted significantly the overall work performance of SMEs of Gboko metropolis. Independently, openness to experience, conscientiousness and extraversion significantly predicted the overall work performance of employees of SMEs in Gboko metropolis. This establishes an implication that traits are vital for work performance among employees of SMEs in Gboko metropolis and therefore should be taken into cognizance.

### 5.3 Recommendation

Based on the findings of this study, the following recommendation is made:

SMEs in Gboko metropolis should include personality traits (psychometric) test in their recruitment process as it predicts work performance.

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ERIN 2ND E-PROCEEDING

# Investigating the Impact of Science and Technology Education Research on Sustainable Development in Africa

**UPU, Francis Terseer<sup>1</sup>, OKWARA, Kalu Okwara<sup>2</sup>, & Adzape, Janet Ngunan<sup>3</sup>**

<sup>1</sup>Department of Integrated Science Education Joseph Sarwuan Tarka University Makurdi

<sup>2</sup>Department of Biology Education Joseph Sarwuan Tarka University Makurdi

<sup>3</sup>Department of Chemistry Education, Joseph Sarwuan Tarka University Makurdi

[francisupu@yahoo.com](mailto:francisupu@yahoo.com) <sup>1</sup>; [okwarakalu@gmail.com](mailto:okwarakalu@gmail.com) <sup>2</sup>, [adzapejanet@yahoo.com](mailto:adzapejanet@yahoo.com) <sup>3</sup>

## ABSTRACT

*This study investigated the relationship between science and technology education research and sustainable national development in Nigeria, Africa. The study was guided by three objectives, three research questions and three hypotheses. The study adopted correlational research design. The sample size of 256 educational stakeholders in Nigeria was drawn from the population of 26,155 using multi-stage sampling technique. Instrument for data collection was developed by the researchers titled Science and Technology Education Research and Sustainable Development Questionnaire (STERSDQ) was validated by three experts. Reliability coefficient of STERSDQ was established at .84 using Cronbach-Alpha Method. Pearson Product Moment Correlation Coefficient (PPMCC) was used to answer research questions and also for testing of the hypotheses at 0.05 significance level. Findings of the study indicated a higher and significant positive relationship between science and technology education research and sustainable national development in Nigeria, on the indicators such as policy effectiveness, environmental awareness, and social inclusion. Based on the findings the researchers concluded that science and technology education research has higher positive relationship on sustainable national development. In line with the findings of the study researchers recommended amongst other things that African countries should continue to strengthen research policy linkages and institutional capacity building in order to maximize the contribution of science and technology education research for sustainable national development in the African continent.*

KEYWORDS: Impact, Education Research, Sustainable Development, Africa

## INTRODUCTION

Research in Science and technology education is widely recognized throughout the world as the cornerstone for sustainable national development. Science and technology education research can be described as systematic inquiry into teaching, learning, education policy, curriculum, and related social processes that underpin the overall development of the countries of world, United Nations Educational, Scientific and Cultural Organization (UNESCO, 2020). In Africa, research in science and technology education plays a crucial role in diagnosing key challenges, providing evidence-based solutions for decision making, and guiding reforms that facilitate sustainable national development outcomes of the African nations Nigeria inclusive. Ali (2024) reiterated that science and technology education research is a veritable tool for addressing economic transformation, environmental protection, and social inclusion, Nigeria in particular and Africa in general. According to Tikly, (2019) science and technology education research equips individuals of the country with the desirable knowledge, skills and values necessary to participate effectively in the society to support

economic growth, reduce poverty, and promote environmental stewardship that could lead to sustainable of overall national development.

United Nations (2015) posits that sustainable development is the global priority widely referred to as the development that could meet the present societal needs without compromising the ability of future generations to meet their own needs. Sustainable development encompasses social equity, economic growth, and environmental protection that centred on United Nations Sustainable Development Goal 4 (SDG 4) vision 2030. It is aimed at ensuring inclusive and equitable quality science and technology education to promote lifelong learning opportunities for all citizens. Sustainable development requires inclusive education that ensures equitable opportunities for all learners, regardless of the gender, socioeconomic status, disability or geographic location.

In Africa, science and technology education research has become increasingly important for sustainable national development as all countries of the world are striving hard to meet the United Nations' Sustainable Development Goal 4 vision 2030 (United Nations, 2015). This is because science and technology education research has the capacity to contribute immensely to sustainable national development by equipping individuals, educational stakeholders, government, policymakers, educators, communities, and international partners with actionable insights that could help address longstanding inequalities. Creswell and Creswell (2018) maintained that science and technology education research if well implemented have the potential of promoting capacity building, and aligning education with labour market necessary for environmental priorities of the citizens that could meet 2030 vision of UN agenda.

In Africa, achieving UN Sustainable Development Goal 4 vision 2030 is very critical particularly, given the continent rapidly growing population, abundant natural resources, but persistently facing with many challenges such as poverty, inequality, environmental degradation, and limited infrastructure (World Bank, 2018). This means that appropriate research in science and technology education could help to bridge these gaps by providing policymakers, educators and educational stakeholders with adequate knowledge and understanding of the complex relationships between education and sustainable development across all sectors of national economic growth. This means that through evidence-based insights, research informs policies could address the persistent educational challenges such as inequity, poor infrastructure, teacher shortages, and mismatch between education and labour market needs in our contemporary societies. According to Tikly, (2019) one of the most direct contributions of science and technology education research on sustainable national development is its influence on policy formulation and educational governance as well as environmental sustainability.

The implication is that science and technology education research is capable of providing policymakers with empirical evidence that informs reform agendas, resource allocation, and programme design and evaluation. Zhang, (2024), investigated the relationship between education research on poverty and national sustainability the findings showed a higher positively correlated improvements in the national sustainability indicators across Africa's major economic sectors. This evidence reinforces the argument for government to increased investment and interventions in educational research to support human capacity building development and sustainable outcomes across socioeconomic of every nation.

Science and technology education research is also a strong pillar that supports multistakeholder policy-making frameworks that provides mechanisms for youth-inclusivity. Its facilitates policy review platforms to engage educators, learners, civil society organisations, and decision-makers in collaboration with evidence dialogues to generate contextual relevant

opportunities for advancing UN SDG 4 vision 2030 in Nigeria, Africa. These platforms provide spaces for systematic review of the programme implementation progress and the alignment of educational systems with emerging social and labour market needs. Rakgwata and Randima, (2024) carried out a study on inclusive education the results reveal systemic gaps in policy implementation, such as inadequate teacher preparation and resource constraints, which prevent policies from realizing full inclusion outcomes. This study on education inclusivity policies aimed at expanding access to schools for students living with disabilities and the lingering barriers related to resources and social attitudes that continue to be impediment for full participation of students in education systems. Inclusive education research underscores the necessity of indigenous knowledge systems as critical resources for sustainable learning practices that resonate with local cultural contexts, thereby enhancing community ownership and sustainability of educational interventions for the sustainable development of African countries Nigeria inclusive.

The important of science and technology education research cannot be overemphasized. This is because science and technology education research is capable of contributing for economic sustainability of Africa by generating insights on how education systems align better with labour market needs and support innovation and economic growth of the African countries Nigeria inclusive (Zickafoose, 2024). Research into the role of science and technology education in fostering innovation orientation and economic growth have shown that quality education enhances every aspect of country capacity building by stimulating entrepreneurship for sustainable national development. This is central to sustainable national development because it supports individuals' resilience, job creation, and economic diversification in a rapidly changing global economy (World Bank, 2018). Furthermore, studies on the relationship between science and technology and economic growth indicated that science and technology education research has a significantly influence on the employment outcomes, productivity, and social mobility that is the key drivers for the sustainable economic development.

Science and technology education research in the tool that plays a pivotal role in informing skills development strategies, particularly in emerging areas like environmental sustainability and Information Communication Technology (ICT). Various studies indicate that incorporating digital skills in education could supports workforce readiness and enhances opportunities for economic participation that ensure an environmental sustainability.

Environmental sustainability is an integral component of the SDGs that requires science and technology education to equip learners with the knowledge and skills necessary to support environmental stewardship (Abu-Alfoul, 2024). Science and technology education research can help identify effective strategies for integrating sustainable education such as climate change, resource conservation, and ecological ethics into science and technology curricula. By examining learners' behaviours and outcomes, researchers can generate evidence on how education influences environmental attitudes and sustainable practices, thereby informing education policy markers about the practices that aligns with climate goals. Africa generally, Nigeria in particular, where environmental challenges such as desertification, water scarcity, and biodiversity loss are pressing issues, incorporating environmental sustainability into science and technology education will supports community resilience and long-term development.

Abdullahi, (2024) opine that enhancement of quality education to achieve UN SDG4 vision 2030 depends on good research in science and technology education. This is because quality research lays groundwork for sustainable livelihoods and socio-economic mobility and growth. Quality education encompasses not only having access to schools, but also the effectiveness of teaching, relevance of the curriculum to the immediate community, and

alignment of education with future job markets. Nketsia and Opoku, (2024) observed that quality science and technology education research have potential for strengthen pedagogical skills and curriculum design to prepare better educators to face the contemporary challenges and achieve UN SDG 4 vision 2030 in Sub-Saharan Africa. Science and technology education research helps education stakeholders to identify patterns of inequity and develop evidence-based strategies to promote inclusivity. Research on local knowledge inclusion in education policy highlighted the importance of integrating community-based ways of knowing into national policies to strengthen implementation and promote culturally grounded learning that benefits marginalized groups, including learners with disabilities.

In spite the importance of science and technology education research, Africa countries including Nigeria continued to face significant hurdles in translating educational research into sustainable outcomes. Through the analysis of science and technology education research on specific barriers such as limited access to quality education, teacher shortages, inequitable resource distribution, infrastructure deficits, gender disparities, and rural-urban divides remain persistent across many African countries Nigeria inclusive which still have spotlight to hinder progress toward achieving United Nations SDG 4 vision 2030.

Other challenges hindering utilization of science and technology education research for sustainable development are; continental cultural diversity, linguistic, economic, and environmental needs. This paper investigated the multifaceted ways in which science and technology education research influence sustainable development across Africa Nigeria inclusive, highlighting empirical evidence, policy implications, and transformative pathways. Studies indicate that inadequate funding, teacher shortages, and socio-cultural barriers collectively undermine the delivery of quality education, emphasizing the need for systemic reforms within education sectors (World Bank, 2018). Science and technology education research shows that science and technology education curriculum integrated sustainability themes such as environmental stewardship, civic participation, and digital literacy in order to produce learners who are better equipped to contribute to socio-economic development of our contemporary society.

### **Statement of the problem**

Despite the potential benefits of science and technology education research on sustainable development many African countries Nigeria inclusive still face constraints of investing in the research. Challenges include limited funding for research activities, gaps in data quality and availability, and insufficient integration of research findings into policy making and practice. To overcome these challenges, increased investment in research infrastructure, capacity-building for researchers, and stronger partnerships between academic institutions, governments and international organizations are needed. Science and technology education research in Africa faces constraints include limited funding for research activities, gaps in data quality and availability, and insufficient integration of research findings into policy making and practices. To overcome these challenges, increased investment in research infrastructure, capacity-building for researchers, and stronger partnerships between academic institutions, governments, and international organizations are needed. Studies exploring quality education and innovation orientation in African contexts show that quality educational outcomes correlate with enhanced innovation capacity in organizations, indicating the broader societal benefits of education research that informs teaching practice and curriculum reforms.

### **Objective of the Study**

The main objective of this study is to investigated the relationship of science and technology education research on sustainable development in Nigeria, Africa. Specifically, the study will seek to:

1. assess the relationship of science and technology education research on environmental sustainability practices across Nigeria.
2. explore relationship of science and technology education research on policy formulation on sustainable development in Nigeria.
3. determine the relationship of science and technology education research on innovation and technological capacity building among Nigeria youth.

## **Research Questions**

The following research questions were raised to guide the study:

1. What is the relationship of science and technology education research on environmental sustainability practices across Nigeria?
2. What relationship of science on technology education research and policy formulation for sustainable development in Nigeria?
3. What is the relationship of science and technology education research on innovation and technological capacity building among Nigeria youth?

## **Hypotheses**

**Ho<sub>1</sub>:** There is no relationship of science and technology education research on environmental sustainability practices in Nigeria.

**Ho<sub>2</sub>:** There is no relationship of science and technology education research on policy formulation for sustainable development in Nigeria.

**Ho<sub>3</sub>:** There is no relationship of science and technology education research on innovation and technological capacity building among Nigerian youth.

## **METHODOLOGY**

The study adopted correlational research design. The population of the study was 26,155 educational stakeholders in Nigeria. The sample size of 256 was drawn from stakeholders in education by using multi-stage sampling technique was used for the selection of Nigerian educational stakeholders for the study.

The instrument used for data collection was Science and Technology Education Research and Sustainable Development Questionnaire (STERSDQ) which was developed by the researchers. STERSDQ consisted of 30 items, anchored on four-point scale of strongly agree (SA) = 4 points, agree (A) =3 points, disagree (D) =2 points and strongly disagree (SD) =1 point for positively worded items and in the reverse order for the negatively worded items. The validation of the instrument was done by three experts. One in the Department of Integrated Science Education, one Department of Agriculture Education and one from measurement and evaluation the Department of Guidance and Counselling Education both of them are from Joseph Sarwuan Tarka University, Makurdi.

The reliability of STERSDQ was calculated using Cronbach Coefficient Alpha test method which gave the value of 0.84. This value indicated a positive relationship within the test items which showed that items of the instrument are both internally consistent and reliable. Pearson Product Moment Correlation Coefficient (PPMCC) was used to answer research questions and also for testing of hypothesis at 0.05 significance level. Correlation coefficient (r) values from 0.10-0.49 was considered low relationship; r-value from 0.50-0.69 was considered to be moderate relationship, while r-value from 0.70-1.0 was considered high relationship. On the other hand, in testing of hypotheses any hypothesis with a significant

value less than p-value of 0.05 was rejected while a hypothesis that had significant value equal to or greater than p-value of 0.05 was withheld.

## RESULTS

**Research Question 1:** What is the relationship of science and technology education research and environmental sustainability practices in Nigeria?

**Table 1: Correlation Analysis on relationship of Science and Technology Education Research and Environmental Sustainability**

Variables	N	r
Science and Technology Education Research	256	.74
Environmental sustainability		

Results in Table1; shows a Pearson' coefficient (r) value of .74 which indicates high positive relationship of science and technology education research on environmental sustainability practices in Nigeria. This means that Science and Technology Education Research correlates environmental sustainability with r-value greater than 0.69. This result is further investigated by testing hypothesis one in the Table 2.

**Hypothesis 1:** There is no relationship between science and technology education research and environmental sustainability practices in Nigeria.

**Table 2: Correlation Coefficient of relationship between Science and Technology Education Research and Environmental Sustainability**

Variables	N	r	p-value	Significant value	Remark
Science and Technology Education Research	256	.74	.050	.037	Significant
Environmental sustainability					

Table 2; results reveal that the correlational analysis on the relationship between science and technology education research and environmental sustainability have a p-value of .050 and significant value of .037. This significant value of .037 is less than p-value of .050 (i.e.  $p=.050>.037$ ). With this result, the null hypothesis one which stated that there is no relationship between science and technology education research and environmental sustainability practices in Nigeria is rejected. This means that there is a relationship between science and technology education research and environmental sustainability practices in Nigeria.

**Research Question 2:** what is the relationship of science and technology education research on policy formulation for sustainable development in Nigeria?

**Table 3: Correlation Analysis on the relationship of Science and Technology Education Research and Police Formulation for Sustainable Development**

Variables	N	r
Science and Technology Education Research	256	.84
policy formulation for sustainable development		

Results in Table 3; show a Pearson' coefficient (r) of .84 which shows a high positive relationship of science and technology education research and policy formulation for sustainable development in Nigeria. This means that STER correlates policy formulation that

could lead to sustainable development with r-value above 0.69, this result is further investigated by testing hypothesis two in the Table 4.

**Hypothesis 2:** There is no relationship of science and technology education research on police formulation for sustainable development in Africa.

**Table 4: Correlation Coefficient of the relationship of Science and Technology Education Research on Police Formulation for Sustainable Development**

Variables	N	r	p-value	Significant value	Remark
Science and Technology Education Research policy formulation	256	.84	.050	.032	Significant

Table 4; results reveal that the correlational analysis on the relationship of science and technology education research on policy formulation for sustainable development in Nigeria have a p-value of .050 and significant value of .032. This significant value of .032 is less than p-value of .050 (i.e.  $p = .050 > .032$ ). With this result, the null hypothesis two which stated that there is no relationship of science and technology education research on police formulation for sustainable development in Nigeria is rejected. This means that there is a relationship of science and technology education research on policy formulation for sustainable development in Nigeria.

**Research Question 3:** What is the relationship of science and technology education research on innovation and technological capacity building among Nigeria youth?

**Table 5: Correlation Analysis on relationship of Science and Technology Education Research on Innovation and Technological Capacity Building**

Variables	N	R
Science and Technology Education Research Innovation and capacity building among the youth	256	.72

Results in Table5; reveals a Pearson' coefficient (r) of .72 which shows a high positive relationship of science and technology education research on innovation and technological capacity building among the youth in Nigeria. This means that STER have a highly correlates Innovation and technological capacity building among the youth with r-value above 0.69, this finding is further investigated by testing hypothesis three in the Table 6.

**Hypothesis 3:** There is no relationship of science and technology education research on innovation and technological capacity building among Nigerian youth

**Table 6: Correlation Coefficient of Science and Technology Education Research on innovation and technological capacity building among Nigerian youth.**

Variables	N	R	p-value	Significant value	Remark
Science and Technology Education Research policy formulation	256	.72	.050	.032	significant

Table 6; results reveal that the correlational analysis on the relationship of science and technology education research on innovation and technological capacity building among Nigerian youth have a p-value of .050 and significant value of .042, this significant value is

less than p-value of .050 (i.e.  $p = .050 > .042$ ). With this result, the null hypothesis three which stated that There is no relationship of science and technology education research on innovation and technological capacity building among Nigerian youth is rejected. This means that there is a relationship of science and technology education research on innovation and technological capacity building among Nigerian youth.

### **Summary of Major Findings**

1. There is a relationship of science and technology education research on environmental sustainability practices in Nigeria.
2. There is a relationship of science and technology education research on policy formulation for sustainable development in Nigeria.
3. There is a relationship of science and technology education research on innovation and technological capacity building among Nigerian youth

### **Discussion of Findings**

Findings of the study revealed a positive higher relationship of science and technology education research on environmental sustainability practices in Nigeria. This finding is in consonance with that of Nketsia and Opoku (2024) who revealed that science and technology education research has a higher positive relationship on environmental sustainability in African country Nigeria.

Results of this study also revealed a higher and positive relationship of science and technology education research on policy formulation for sustainable development in Nigeria. This finding is in line with Tikly, (2019) and Zhang (2024) who in their various studies found out that science and technology education research correlates policy formulation for sustainable national development of the African countries.

Findings of this study showed a higher positive relationship of science and technology education research on innovation and technological capacity building among Nigerian youth. This finding is in agreement with that Abdullahi, (2024) and Ali, (2024) who revealed that science and technology education research has a positive relationship on innovation and technological capacity building among African youth Nigeria inclusive.

### **Conclusion**

Based on the findings of the study the researchers concluded that science and technology education research has higher positive relationship on sustainable development in Nigeria, Africa. This higher positive relationship is prominent in the area of environmental sustainability, policy formulation that enable sustainable national development as well as innovation and technological capacity building among African youth including Nigeria.

### **Recommendation**

In line with the findings of the study researchers recommended that:

1. African countries should continue to strengthen research policy linkages and institutional capacity building in order to maximize the contribution of science and technology education research for sustainable national development in the Nigeria country.
2. Governments and development partners should establish mechanisms to ensure science and technology education research informs policy formulation

and implementation, particularly for achieving United Nations SDG 4 vision 2030. Stakeholders in Nigeria and Africa as whole also should explore effective strategies for enhancing the integration of science and technology education research into effective national sustainable development plans.

3. Government at all levels should invest in institutional capacity building programmes by enhancing governance structures that ensure research findings are operationalized to maximize education's contribution to sustainable development.

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# Impact of Industry-Based Training on Employability Skills of Automobile Technology Students in Colleges of Education in North Central Nigeria

Alfred D. Tyav PhD<sup>1</sup>, Onyilo Regina Igogbe PhD<sup>2</sup>, & Kpandam Peter Yohanna<sup>3</sup>

<sup>1,2</sup> Department of Technology and Industrial Studies, Rev. Fr. Moses Orshio Adasu University, Makurdi Benue state

<sup>3</sup> Department of Technical Education, College of Education, Akwanga, Nasarawa State.

Email Addresses: [dyav@bsum.edu.ng](mailto:dyav@bsum.edu.ng)<sup>1</sup>; [regonyilo@gmail.com](mailto:regonyilo@gmail.com)<sup>2</sup>; [peterkpandam2014@gmail.com](mailto:peterkpandam2014@gmail.com)<sup>3</sup>

## ABSTRACT

*Industry-Based Training (IBT) plays an essential role in bridging the gap between theoretical knowledge and practical competencies in technical and vocational education. This study examined the impact of industry-based training on the employability skills of automobile technology students in six selected Colleges of Education in North Central Nigeria. Specifically, the study examined the extent to which IBT influences employability skills, determined the relationship between the duration of IBT and students' proficiency in technical and soft skills, and assessed the effectiveness of IBT facilities, workshops, and tools used for training. The study adopted a descriptive survey research design. The population comprised 112 automobile technology students, from which 24 respondents were sampled. Data were collected using a structured questionnaire titled Industry-Based Training and Employability Skills Questionnaire (IBTESQ). Descriptive statistics (mean and standard deviation) and Spearman Rank Correlation were used for analysis. Findings revealed that IBT significantly enhances students' employability skills, a positive relationship exists between IBT duration and skill proficiency, and the facilities and tools used for IBT moderately enhance skill acquisition. The study concludes that effective implementation of IBT improves students' technical competence and workplace readiness. It recommends improved industry partnerships, longer training duration, and provision of modern workshop facilities in Colleges of Education.*

KEYWORDS: Industry-Based Training, Employability Skills, Automobile Technology, Technical Education, Colleges of Education.

## Introduction

Technical and Vocational Education and Training (TVET) is widely recognized as a critical driver of national development, industrial productivity, and workforce competitiveness. Globally, TVET systems are designed to equip learners with occupational competencies, practical skills, and work attitudes necessary for employment and self-reliance. The UNESCO (2016) emphasizes that effective TVET systems must align educational outcomes with labour market demands to facilitate smooth school-to-work transition. Similarly, the International Labour Organization (2019) notes that strengthening workplace learning mechanisms significantly enhances youth employability and reduces skills mismatch. In Nigeria, technical education is positioned as a strategic component of the national education system. Colleges of Education offering Automobile Technology programmes are mandated to produce

competent technical teachers and middle-level manpower capable of performing effectively in automotive workshops, service centers, and related industries. The National Commission for Colleges of Education (2020) prescribes minimum standards requiring industrial training as an integral part of technical education programmes to ensure that graduates acquire both pedagogical competence and occupational proficiency.

Automobile Technology has undergone rapid transformation due to advancements in digital and electronic automotive systems. Modern vehicles incorporate electronic fuel injection systems, computerized engine control modules, onboard diagnostic systems (OBD II), anti-lock braking systems (ABS), hybrid propulsion systems, and advanced driver-assistance systems. These innovations require technicians to possess advanced diagnostic reasoning, computer interfacing skills, and system integration competence. The International Labour Organization (2020) reports that technological transformation in industrial sectors has increased the demand for higher-order technical and problem-solving skills, particularly in engineering-related occupations. Consequently, Automobile Technology graduates must demonstrate both theoretical understanding and industry-relevant practical expertise.

Industry-Based Training (IBT), also known as industrial attachment or work-integrated learning, is a structured educational strategy designed to bridge the gap between classroom instruction and real-world industry practice. IBT exposes students to authentic workplace environments where they engage in hands-on activities under professional supervision. According to UNESCO (2016), work-integrated learning enhances experiential knowledge acquisition by allowing students to apply theoretical concepts to practical tasks in real settings.

Empirical studies in Nigeria further reinforce the importance of industry exposure. Okoye and Edokpolor (2021) found that industrial work experience significantly improves employability competencies among Technical and Vocational Education undergraduates. Similarly, Nguwap and Umoru (2022) reported that work-based learning positively influences students' employment prospects by strengthening their practical and workplace skills. In the same vein, Inuwa and Abubakar (2023) established that competency developed through Students Industrial Work Experience Scheme (SIWES) significantly predicts employability outcomes among Nigerian graduates.

Beyond technical skills (hard skills), modern industries increasingly emphasize transferable or soft skills. The International Labour Organization (2019) highlights that communication skills, teamwork, adaptability, and work ethics are critical determinants of workplace success. Research by Adegbite and Hoole (2024) demonstrated that work-integrated learning significantly enhances communication, analytical reasoning, and adaptability among engineering students. Furthermore, Jamilu, Paris, and Sambo (2024) found that structured industrial placements in Colleges of Education improved students' teamwork and problem-solving abilities, although limited industry collaboration reduced overall effectiveness.

In the Nigerian context, collaboration between technical institutions and industry remains a key determinant of effective skill acquisition. Ogbebor and Osuyi (2024) emphasized that strong institutional–industry partnerships significantly improve skills acquisition in motor vehicle mechanics programmes. However, weak collaboration mechanisms often limit exposure to modern automotive tools and technologies. Obi and Ojo (2025) further noted that while vocational training enhances employability among Nigerian youths, systemic challenges such as inadequate facilities and inconsistent supervision reduce training effectiveness.

In North Central Nigeria, concerns have emerged regarding the employability readiness of some Automobile Technology graduates. Employers have reported deficiencies in modern diagnostic competence, electronic troubleshooting skills, professional communication, and workplace ethics. Shehu, Garba, and Ahmed (2022) observed that inadequate supervision and

insufficient hands-on industrial exposure negatively affect the school-to-work transition of automobile technology graduates in Northern Nigeria.

Despite the policy mandate of the National Commission for Colleges of Education requiring industrial training, questions remain about the extent to which Industry-Based Training effectively enhances employability skills in Colleges of Education. Variations in duration, supervision quality, training facilities, institutional ownership, and timing within the academic programme, prior student experience, and satisfaction levels may influence skill acquisition outcomes.

Given the increasing technological sophistication of the automotive sector and the rising emphasis on employability competencies, it is imperative to empirically examine the impact of Industry-Based Training on the employability skills of Automobile Technology students in Colleges of Education in North Central Nigeria. This study therefore investigates the extent to which IBT enhances technical and soft skills and examines moderating variables that may influence its effectiveness.

### **Statement of the Problem**

Industry-Based Training is incorporated into the curriculum of Automobile Technology programmes in Colleges of Education with the expectation that exposure to real industry environments will enhance students' practical competence and employability. The intended outcome is that graduates will possess contemporary diagnostic skills, technical proficiency, and professional workplace behaviours aligned with modern automotive industry standards.

However, despite this curricular provision, evidence suggests that some graduates continue to exhibit deficiencies in essential employability skills. Employers have reported gaps in practical diagnostic ability, limited proficiency in computerized automotive tools, weak communication skills, inadequate teamwork orientation, and poor professional work ethics. These deficiencies suggest a possible mismatch between institutional training outcomes and labour market expectations. Shehu et al. (2022) found that insufficient hands-on industrial exposure undermines job readiness among automobile technology graduates. Jamilu et al. (2024) also reported that limited internship opportunities and weak industry partnerships reduce the effectiveness of work-integrated learning programmes in Nigerian Colleges of Education. Furthermore, Ogbemor and Osuyi (2024) identified inadequate institutional–industry collaboration as a major barrier to effective technical skill development.

In addition, inconsistencies in IBT implementation across institutions raise further concerns. Differences in attachment duration, supervision mechanisms, availability of modern automotive facilities, and evaluation procedures may influence the level of skills acquired. Gender-based participation disparities and varying levels of student satisfaction may also affect employability outcomes.

Although prior studies have examined work-based learning in general technical education contexts, there is limited empirical evidence specifically investigating the impact of Industry-Based Training on the employability skills of Automobile Technology students in Colleges of Education in North Central Nigeria. It remains unclear whether IBT significantly enhances both technical and soft skills, and whether moderating variables such as duration, supervision quality, facilities, institutional type, timing, prior experience, and satisfaction influence its effectiveness.

Therefore, the problem of this study is to determine the extent to which Industry-Based Training influences the employability skills of Automobile Technology students in Colleges of Education in North Central Nigeria and to examine the factors that moderate this relationship.

The purpose of this study is to determine the impact of industry-based training on the employability skills of automobile technology students in Colleges of Education in the North Central States of Nigeria. Specifically, the study seeks to:

1. Examine the extent to which industry-based training (IBT) influences the employability skills of automobile technology students in Colleges of Education (COEs) in North Central Nigeria.
2. Determine the relationship between the duration of (IBT) and students' proficiency in technical and soft skills.
3. Assess the effectiveness of (IBT) facilities, workshops, and tools used for automobile technology education in Colleges of Education.

### **Research Questions**

The following research question guided the study

1. How does industry-based training (IBT) influence the employability skills of automobile technology students in Colleges of Education in North Central Nigeria?
2. What is the relationship between the duration of (IBT) and students' proficiency in technical and soft skills?
3. How effective are the facilities, workshops, and tools used (IBT) in enhancing students' skills acquisition?

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

- H<sub>01</sub>: There is no significant difference in the mean influence of industry-based training (IBT) on the employability skills of automobile technology students in Colleges of Education in North Central Nigeria.
- H<sub>02</sub>: There is no significant difference in the relationship between the duration of (IBT) and students' proficiency in technical and soft skills.
- H<sub>03</sub>: There is no significant difference in students' skills acquisition based on the facilities, workshops, and tools used during (IBT).

### **Methodology**

The study adopted a descriptive survey research design to examine the impact of industry-based training (IBT) on the employability skills of automobile technology students in Colleges of Education in North Central Nigeria. The study was conducted in six (6) Colleges of Education offering Automobile Technology programmes located in four selected states in North Central Nigeria, specifically Benue, Nasarawa, Plateau, and the Federal Capital Territory (FCT). The population for the study consists of 112 respondents comprising 88 automobile technology students and 24 lecturers / industry supervisors. A sample of 24 students was selected using the simple random sampling technique to ensure that each member of the population had an equal chance of being selected. Data for the study were collected using a structured questionnaire titled *Industry-Based Training and Employability Skills Questionnaire (IBTESQ)*. The instrument contained items organized into three sections covering the influence of IBT on employability skills, the relationship between the duration of IBT and students' proficiency in technical and soft skills, and the effectiveness of IBT facilities, workshops, and tools in enhancing skills acquisition. The questionnaire items were structured on a four-point Likert scale of Strongly Agree, Agree, Disagree, and Strongly Disagree. The instrument was

subjected to face and content validation by experts in automobile technology education and measurement and evaluation from Rev. Fr. Moses Orshio Adasu University, Makurdi to ensure clarity and relevance of the items. The reliability of the instrument was determined using the Cronbach Alpha method, which yielded a reliability coefficient of 0.82, indicating that the instrument was reliable for the study.

The questionnaire was administered directly to the respondents by the researcher and retrieved after completion to ensure a high response rate. Data collected were analyzed using mean and standard deviation to answer research questions one and three, while Spearman Rank Correlation was used to determine the relationship between the duration of industry-based training and students' proficiency in technical and soft skills. A criterion mean of 2.50 was used as the decision rule for interpreting the responses.

## Results

### Research Question 1

How does industry-based training influence the employability skills of automobile technology students?

**Table 1: Influence of IBT on Employability Skills**

S/N	Item	Mean	SD	Decision
1	IBT improves students' practical automobile repair skills	3.58	0.61	Agree
2	IBT enhances students' diagnostic and troubleshooting abilities	3.46	0.64	Agree
3	IBT develops teamwork and communication skills	3.33	0.72	Agree
4	IBT increases students' confidence in handling automotive tools	3.50	0.59	Agree
5	IBT prepares students for employment in automobile industries	3.63	0.56	Agree

**Grand Mean = 3.50**

The results in Table 1 show that industry-based training has a positive influence on the employability skills of automobile technology students in Colleges of Education in North Central Nigeria. The item mean scores ranged from **3.33 to 3.63**, all of which are above the criterion mean of **2.50**, indicating that respondents agreed that industry-based training improves their practical repair skills, diagnostic abilities, teamwork, communication skills, and confidence in handling automotive tools. The **grand mean of 3.50** indicates a high level of agreement among respondents, suggesting that industry-based training significantly enhances the employability skills of automobile technology students.

### Research Question 2

What is the relationship between IBT duration and students' proficiency in technical and soft skills?

**Table 2: IBT Duration and Skill Proficiency**

Variable	N	R	p-value	Decision
IBT Duration & Skill Proficiency	24	0.62	0.001	Significant

The result in Table 2 shows the relationship between the duration of industry-based training (IBT) and students' proficiency in technical and soft skills. The analysis using Spearman Rank Correlation produced a correlation coefficient of  $r = 0.62$  with a **p-value of 0.001**, which is less than the **0.05 level of significance**. This indicates that there is a **positive and statistically significant relationship** between the duration of IBT and students' proficiency in technical and soft skills. This means that students who spend more time in industry-based training tend to develop higher levels of technical competence and employability skills such as teamwork, communication, and problem-solving. The finding suggests that longer exposure to industrial environments provides students with greater opportunities to practice and improve their skills, thereby enhancing their overall employability.

### Research Question 3

How effective are the facilities, workshops, and tools used in IBT?

**Table 3: Effectiveness of IBT Facilities and Tools**

S/N	Item	Mean	SD	Decision
1	Industrial workshops contain relevant automobile equipment	3.21	0.75	Agree
2	Modern diagnostic tools are available for training	3.04	0.81	Agree
3	Students are allowed to operate industry equipment	3.17	0.73	Agree
4	Industrial supervisors provide adequate practical guidance	3.29	0.68	Agree
5	Training facilities support skill acquisition	3.25	0.70	Agree

**Grand Mean = 3.19**

The results in Table 3 indicate that the facilities, workshops, and tools used during industry-based training contribute to students' skill acquisition. The item mean scores ranged from **3.04 to 3.29**, all of which are above the criterion mean of **2.50**, indicating that respondents agreed that the available facilities and tools support their learning during industrial training. However, the **grand mean of 3.19** suggests that the facilities and tools are **moderately effective** in enhancing students' skill acquisition. This implies that although the available industrial facilities assist students in developing practical skills, there is still a need for improvement in the provision of modern automotive equipment and training resources to further strengthen the effectiveness of industry-based training.

### Discussion of Findings

The findings revealed that industry-based training significantly improves the employability skills of automobile technology students. This implies that exposure to real industrial environments helps students acquire practical competencies such as vehicle diagnostics, repair techniques, teamwork, and communication skills. This finding supports the view of Aina (2021), who reported that industrial training enhances students' practical skills and work readiness.

The study also found a significant positive relationship between the duration of IBT and students' proficiency in technical and soft skills. This suggests that longer industrial training periods provide students with more opportunities to practice and master automotive skills. The finding aligns with Yorke (2019), who emphasized that extended workplace training improves students' employability competencies.

Furthermore, the results indicated that facilities, workshops, and tools used during IBT moderately enhance skill acquisition among students. Although the facilities contribute positively to training outcomes, there is still a need for improvement in terms of modern automotive equipment and advanced diagnostic tools. This finding corroborates the study by Ogbuanya and Bakare (2023), which highlighted that inadequate industrial facilities limit the effectiveness of technical training programmes. Overall, the results demonstrate that industry-based training is an essential component of automobile technology education as it bridges the gap between theoretical instruction and practical industry experience.

## Conclusion

The study examined the impact of industry-based training on the employability skills of automobile technology students in Colleges of Education in North Central Nigeria. The findings revealed that IBT significantly enhances students' practical skills, improves their workplace competencies, and positively relates to the duration of training exposure. The facilities and tools available during IBT were found to moderately support students' skill acquisition. Therefore, effective implementation of industry-based training programmes is essential for producing competent graduates capable of meeting the demands of the modern automobile industry.

## Recommendations

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

1. Colleges of Education should strengthen partnerships with automobile industries to provide students with better industrial training opportunities.
2. The duration of industry-based training should be extended to allow students to gain deeper practical experience.
3. Government and educational institutions should provide modern workshop facilities and diagnostic equipment to enhance skill acquisition.
4. Industrial supervisors should provide structured mentorship to guide students during their training period.
5. Curriculum developers should integrate more practical industry-oriented components into automobile technology programmes.

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# Community-Based Education Programmes and Sustainable Rural Development in Africa: The Cross River State Experience

**AKATA, Charles Ekpung, Ph.D**  
Empirical Research Institute of Nigeria, Uyo  
[drakata@erin.com.ng](mailto:drakata@erin.com.ng)

## ABSTRACT

*Community-Based Education Programmes (CBEPs) have emerged as key strategies for promoting sustainable rural development, particularly in regions where access to formal education is limited. This study investigated the contributions of CBEPs to economic empowerment, social inclusion, human capital development, and environmental sustainability in rural communities of Cross River State, Nigeria. Adopting a descriptive survey design, the research targeted a population of 5,225 rural residents participating in various CBEPs, with a stratified random sample of 362 respondents selected for the study. Data were collected using structured questionnaires and interview guides, and analyzed using both descriptive statistics and Pearson correlation coefficients to examine relationships between programme participation and developmental outcomes. Findings revealed that CBEPs significantly enhance participants' income-generating skills, entrepreneurial capacities, and household livelihoods, demonstrating a strong positive relationship between participation and economic empowerment ( $r = 0.672, p < 0.01$ ). The programmes also promoted social inclusion and community participation, with participants reporting increased confidence, civic engagement, and collaboration within cooperative initiatives ( $r = 0.611, p < 0.01$ ). Furthermore, CBEPs contributed to environmental awareness and sustainable resource management, with participants adopting practices such as reforestation, waste management, and sustainable agricultural methods ( $r = 0.589, p < 0.01$ ). These findings underscore the multidimensional impact of CBEPs in fostering sustainable rural development. The study concludes that CBEPs are effective mechanisms for enhancing economic, social, and environmental outcomes in rural communities. It recommends the expansion of CBEPs, integration of skills and environmental education, adequate funding, participatory implementation, and policy support to strengthen their sustainability and long-term impact. The study contributes to the growing body of knowledge on community-based education and provides evidence-based insights for policymakers, development agencies, and educational practitioners aiming to promote sustainable rural development in Cross River State and similar contexts across Africa.*

**KEYWORDS:** Community-Based Education Programmes, Sustainable Rural Development, Economic Empowerment, Social Inclusion, Human Capital, Environmental Sustainability

## Introduction

Rural development remains a critical challenge in many African countries, where a substantial proportion of the population resides in rural areas characterised by limited access to quality education, inadequate infrastructure, high poverty levels, and restricted economic opportunities. Education has been widely acknowledged as a fundamental driver of sustainable rural development because it enhances human capital, promotes social inclusion, and equips individuals and communities with the knowledge and skills required to improve their livelihoods.

and participate effectively in development processes (UNESCO, 2017; Todaro & Smith, 2020). In this context, community-based education programmes have emerged as viable strategies for addressing educational marginalisation and fostering grassroots development in rural communities.

Community-based education programmes are designed around the specific needs, values, and socio-economic realities of local communities, with strong emphasis on participation, ownership, and relevance (Aderinoye, 2018). Such programmes commonly include adult literacy education, vocational and skills acquisition training, environmental education, and civic education aimed at empowering community members to contribute meaningfully to local development initiatives. Scholars have argued that when education is embedded within community structures, it becomes more responsive to local challenges and more effective in promoting sustainable development outcomes (Rogers, 2019; Okpoko & Eze, 2021).

In Nigeria, community-based education initiatives have been promoted as part of broader efforts to achieve inclusive and sustainable rural development. In Cross River State in particular, several community-driven educational programmes have been implemented to address issues such as low literacy levels, youth unemployment, environmental degradation, and poverty in rural areas. Empirical studies in the state indicate that community-based development projects, including education-related interventions, contribute significantly to improved community participation, environmental awareness, and local capacity building (Ekanem & Ekefre, 2016; Akpan, 2019). These initiatives align with sustainable development principles by integrating education with economic empowerment and environmental sustainability.

Furthermore, evidence from studies conducted in rural Cross River State suggests that community-oriented skills acquisition and adult education programmes have positively influenced income generation, women's empowerment, and self-reliance among rural dwellers (Uko & Nwachukwu, 2020). Such outcomes are central to sustainable rural development, as they enhance the ability of communities to meet present needs without compromising future generations. However, despite these promising outcomes, the effectiveness and sustainability of community-based education programmes often depend on factors such as funding adequacy, community participation, policy support, and institutional coordination (Adewumi & Bello, 2019).

Despite the growing recognition of community-based education as a catalyst for rural transformation, empirical studies that systematically examine its contribution to sustainable rural development in Cross River State remain limited. There is a need for context-specific evidence on how these programmes influence socio-economic development, environmental sustainability, and community empowerment over time. Addressing this gap is essential for informing policy formulation, strengthening programme implementation, and ensuring that community-based education initiatives effectively support sustainable rural development in Cross River State and across Africa.

### **Problem Statement**

Despite sustained policy emphasis on education as a critical instrument for sustainable rural development in Africa, many rural communities continue to experience persistent poverty, low literacy levels, unemployment, and environmental degradation (Todaro & Smith, 2020; UNESCO, 2017). In Nigeria, these challenges are particularly pronounced in rural areas where access to formal education and development opportunities remains limited, thereby constraining community participation in socio-economic transformation (Aderinoye, 2018). In Cross River State, rural communities are characterised by inadequate educational infrastructure, high youth unemployment, and limited skills development opportunities, which

collectively undermine efforts towards sustainable rural development (Ekanem & Ekefre, 2016; Akpan, 2019).

In response to these challenges, community-based education programmes have been introduced as alternative and complementary strategies aimed at providing context-specific learning, promoting skills acquisition, and empowering rural populations to engage actively in development processes (Rogers, 2019). These programmes, which include adult literacy education, vocational and entrepreneurial training, and environmental education, are designed to align educational provision with local development needs (Okpoko & Eze, 2021). Scholars argue that when education is rooted in community participation and ownership, it is more likely to contribute to sustainable development outcomes such as poverty reduction, social inclusion, and environmental sustainability (UNDP, 2019).

However, despite the proliferation of community-based education programmes in Cross River State, there is limited empirical evidence on the extent to which these initiatives contribute to sustainable rural development. Existing studies have largely examined isolated outcomes such as literacy improvement or skills acquisition, with insufficient attention to their integrated and long-term impacts on economic empowerment, social cohesion, and environmental management (Uko & Nwachukwu, 2020). Furthermore, challenges such as inadequate funding, weak institutional support, limited community participation, and poor coordination among implementing agencies continue to undermine the effectiveness and sustainability of these programmes (Adewumi & Bello, 2019).

The lack of comprehensive, context-specific research on the relationship between community-based education programmes and sustainable rural development in Cross River State represents a significant knowledge gap. This gap limits evidence-based policymaking and constrains efforts to strengthen education-driven rural development strategies. Addressing this problem is therefore critical to understanding how community-based education can be effectively leveraged to promote sustainable rural development in Cross River State and, more broadly, across Africa.

### **Research Objectives**

The main objective of this study was to examine the contribution of community-based education programmes to sustainable rural development in Cross River State, Nigeria, within the broader African development context. Specifically, the study sought to:

1. examine the nature of community-based education programmes and their contribution to economic empowerment and livelihood improvement among rural residents in Cross River State;
2. determine how community-based education programmes influence social inclusion, community participation, and human capital development in rural communities of Cross River State; and
3. evaluate the role of community-based education programmes in promoting environmental awareness and sustainable resource management in rural areas of Cross River State.

### **Research Questions**

1. How do community-based education programmes contribute to economic empowerment and livelihood improvement among rural residents in Cross River State?

2. In what ways do community-based education programmes influence social inclusion, community participation, and human capital development in rural communities of Cross River State?
3. How do community-based education programmes promote environmental awareness and sustainable resource management in rural areas of Cross River State?

### **Null Hypotheses**

H<sub>01</sub>: Community-based education programmes do not have a significant contribution to economic empowerment and livelihood improvement among rural residents in Cross River State.

H<sub>02</sub>: Community-based education programmes do not have a significant influence on social inclusion, community participation, and human capital development in rural communities of Cross River State.

H<sub>03</sub>: Community-based education programmes do not have a significant role in promoting environmental awareness and sustainable resource management in rural areas of Cross River State.

### **Literature Review**

#### **Community-Based Education Programmes**

Community-Based Education Programmes (CBEPs) have emerged as vital strategies for promoting sustainable development in rural areas, particularly in African countries where access to formal education is often limited. Unlike conventional formal education systems, which are centrally managed and often uniform in content, CBEPs are flexible, context-specific, and designed to meet the particular learning and development needs of local communities (Aderinoye, 2018; Rogers, 2019). They place a strong emphasis on local participation, ensuring that community members are actively involved in planning, implementing, and evaluating educational initiatives. This participatory approach fosters a sense of ownership and relevance, making educational programmes more effective in addressing local socio-economic challenges (Okpoko & Eze, 2021).

CBEPs typically focus on practical and non-formal learning opportunities, such as adult literacy, vocational skills, entrepreneurship training, health education, environmental awareness, and civic engagement. By equipping individuals with knowledge and skills that are directly applicable to their daily lives and livelihoods, these programmes enhance economic empowerment, improve social inclusion, and strengthen human capital in rural communities (Adewumi & Bello, 2019). In addition, CBEPs often target marginalized groups, including women and youth, who are disproportionately affected by limited access to education and employment opportunities. This focus contributes to reducing inequalities and fostering equitable community development (Uko & Nwachukwu, 2020).

Beyond economic and social benefits, CBEPs are also designed with sustainability in mind. Many programmes incorporate environmental education and awareness initiatives aimed at promoting sustainable resource management, conservation practices, and resilience to ecological challenges (UNDP, 2019). By linking education with practical development outcomes, CBEPs provide communities with the tools to address immediate needs while ensuring that resources and opportunities remain available for future generations.

In the context of Cross River State, CBEPs have been instrumental in bridging gaps in formal education and supporting sustainable rural development. Local communities have benefited from programmes that combine literacy, skills acquisition, and environmental stewardship, leading to improved livelihoods, enhanced community participation, and strengthened social cohesion (Ekanem & Ekefre, 2016; Akpan, 2019). These experiences demonstrate that when education is rooted in community involvement and aligned with local development goals, it becomes a powerful mechanism for achieving long-term, sustainable rural development.

### **Types of Community-Based Education Programmes in Cross River State**

Community-Based Education Programmes (CBEPs) in Cross River State are diverse and designed to address the educational, economic, social, and environmental needs of rural communities. These programmes are tailored to the local context, often implemented in partnership with community leaders, non-governmental organizations, and local education authorities. Broadly, they can be classified into three main types: literacy and non-formal education programmes, skills acquisition and vocational training programmes, and environmental and civic education initiatives.

**1. Literacy and Non-Formal Education Programmes:** Adult literacy and non-formal education initiatives are among the most common forms of CBEPs in Cross River State. These programmes aim to reduce illiteracy among adults who were unable to access formal schooling, particularly in rural and hard-to-reach communities (Aderinoye, 2018). Classes typically focus on reading, writing, numeracy, and basic life skills. The outcomes of these programmes extend beyond literacy, as they empower individuals to participate more actively in economic activities, understand health and governance issues, and contribute to community decision-making processes (Okpoko & Eze, 2021). By enhancing human capital, these initiatives support the broader goal of sustainable rural development.

**2. Skills Acquisition and Vocational Training Programmes:** Another critical type of CBEP in Cross River State involves skills acquisition and vocational training. These programmes provide community members, especially youth and women, with practical skills in areas such as agriculture, tailoring, carpentry, food processing, and entrepreneurship (Uko & Nwachukwu, 2020). By equipping participants with employable skills, these programmes facilitate income generation, reduce poverty, and increase self-reliance. They also encourage local economic development by creating small-scale businesses and stimulating community-level markets. Such initiatives demonstrate the direct link between education and economic empowerment within rural development frameworks.

**3. Environmental and Civic Education Programmes:** Environmental and civic education initiatives represent a third type of community-based education in Cross River State. These programmes focus on promoting sustainable environmental practices, such as waste management, reforestation, and sustainable agriculture, while also educating citizens on civic responsibilities and local governance processes (UNDP, 2019). By fostering awareness and active participation in community affairs, these initiatives contribute to environmental stewardship, social cohesion, and sustainable resource management. Participants learn to engage in decision-making, advocate for local development priorities, and protect natural resources, all of which are critical to the long-term sustainability of rural communities.

Collectively, these types of CBEPs in Cross River State illustrate the holistic approach of community-based education in addressing the multifaceted challenges of rural development. By integrating literacy, vocational skills, and environmental consciousness, these programmes not only enhance individual capabilities but also strengthen community resilience, promote social inclusion, and support sustainable economic and environmental outcomes (Ekanem &

Ekefre, 2016; Akpan, 2019). They underscore the importance of contextualized, participatory education as a catalyst for rural transformation.

### **Community-Based Education Programmes, Economic Empowerment and Livelihood Improvement in Cross River State**

Community-Based Education Programmes (CBEPs) are educational initiatives deliberately designed to meet the unique needs of rural populations while promoting socio-economic development. Unlike formal schooling, CBEPs are flexible, context-specific, and grounded in local realities, making them particularly suitable for rural communities in Cross River State, where access to conventional education is often limited (Aderinoye, 2018; Rogers, 2019). These programmes are typically participatory in nature, with community members actively involved in planning, implementation, and evaluation processes, ensuring that the content and delivery are relevant to the learners' needs and the community's developmental priorities (Okpoko & Eze, 2021).

In Cross River State, the nature of CBEPs encompasses adult literacy and numeracy classes, vocational and skills acquisition training, micro-enterprise development programmes, and agricultural education initiatives. Adult literacy programmes equip rural residents with basic reading, writing, and numeracy skills, enabling them to better manage their personal finances, engage with governmental services, and participate meaningfully in local decision-making processes (Adewumi & Bello, 2019). Vocational training and skills acquisition programmes, including tailoring, carpentry, food processing, and farming techniques, provide participants with employable skills that can generate income and improve household livelihoods (Uko & Nwachukwu, 2020). Agricultural education programmes often introduce improved farming methods, post-harvest management techniques, and sustainable agricultural practices, helping rural farmers increase productivity and market access.

The contribution of these programmes to economic empowerment and livelihood improvement is significant. By equipping community members with practical skills and literacy, CBEPs enhance individuals' capacity to engage in income-generating activities and manage resources efficiently (Ekanem & Ekefre, 2016). For example, women and youth who participate in skills acquisition programmes often establish small businesses or improve existing farm enterprises, thereby increasing household income and reducing dependency on external assistance. The training also fosters entrepreneurial mindsets, encouraging innovation and resilience in the face of economic challenges.

Moreover, CBEPs facilitate broader community-level economic benefits. As rural residents acquire skills and knowledge, they contribute to local markets, stimulate small-scale enterprises, and support value chains within agricultural and service sectors. These outcomes promote self-reliance and strengthen the socio-economic fabric of rural communities, which is essential for sustainable development (Akpan, 2019). By linking education directly with livelihood enhancement, CBEPs demonstrate how context-specific, participatory learning initiatives can serve as powerful tools for poverty reduction, economic empowerment, and long-term rural transformation in Cross River State.

### **Community-Based Education Programmes, Social Inclusion, Community Participation, and Human Capital Development in Rural Communities of Cross River State**

Community-Based Education Programmes (CBEPs) in Cross River State extend far beyond the provision of economic empowerment opportunities, serving as critical instruments for promoting social inclusion, strengthening community participation, and advancing human capital development in rural communities. These programmes are intentionally designed to be

participatory, with community members actively involved in the identification of needs, planning of interventions, decision-making processes, and implementation of educational activities. Such participatory structures foster a strong sense of ownership, accountability, and collective responsibility, which enhances programme relevance, sustainability, and community acceptance (Rogers, 2019). By embedding education within the social and cultural context of rural communities, CBEPs ensure that learning is responsive to local realities and development priorities.

A key strength of CBEPs lies in their capacity to promote social inclusion and equity. Through deliberate targeting and inclusive programme design, CBEPs actively engage marginalised groups, including women, youth, persons with limited formal education, and other disadvantaged populations who are often excluded from conventional educational systems. This inclusive approach reduces social barriers, challenges entrenched inequalities, and provides equal opportunities for participation in learning and development processes. By creating safe and supportive learning environments, CBEPs empower these groups to voice their concerns, develop self-confidence, and participate meaningfully in community affairs, thereby fostering social cohesion and inclusiveness within rural societies (Uko & Nwachukwu, 2020).

In addition, CBEPs enhance community participation by establishing platforms for collective learning, dialogue, and problem-solving. Educational activities such as adult literacy classes, civic education programmes, and community workshops equip participants with essential knowledge and skills to engage effectively in local governance, understand public policies, and contribute to community decision-making forums. Increased literacy and civic awareness enable community members to participate more actively in town meetings, development committees, and local institutions, thereby strengthening democratic practices at the grassroots level (Okpoko & Eze, 2021). Furthermore, skills acquisition and livelihood training programmes often encourage group-based initiatives, including cooperative farming schemes, women's savings and credit groups, and small-scale entrepreneurship clusters. These collective economic activities not only enhance income generation but also promote trust, mutual support, and a collaborative culture, which are essential for sustained rural development (Adewumi & Bello, 2019).

From a human capital development perspective, CBEPs play a vital role in enhancing the knowledge, skills, and competencies necessary for individual and community advancement. Adult literacy and numeracy programmes enable rural residents to access information, manage finances, adopt improved agricultural practices, and support their children's education. Vocational and technical training equips participants with practical and employable skills aligned with local economic opportunities, thereby improving employability and self-reliance. In addition, health, environmental, and civic education initiatives raise awareness about disease prevention, environmental sustainability, and responsible citizenship, contributing to improved quality of life and community wellbeing (Ekanem & Ekefre, 2016). Collectively, these learning experiences foster critical thinking, problem-solving abilities, adaptability, and socio-emotional competencies, which are widely recognised as core components of human capital.

Moreover, CBEPs significantly contribute to the empowerment of vulnerable groups, particularly women and youth, by enhancing their educational attainment, skill levels, and decision-making capacity. Access to education and skills training improves their confidence, social status, and ability to participate in economic and civic activities. Empowered women and youth are more likely to initiate income-generating ventures, engage in community leadership, and advocate for social change, thereby amplifying the developmental impact of CBEPs (Akpan, 2019). This empowerment produces multiplier effects, as educated and skilled

individuals contribute positively to household welfare, community resilience, and intergenerational development.

CBEPs function as catalysts for inclusive and sustainable rural development in Cross River State by simultaneously promoting social inclusion, enhancing community participation, and building human capital. Through their participatory and community-centred approach, these programmes create a continuous cycle of learning, empowerment, and collective action, equipping rural communities with the capacity to pursue long-term social, economic, and environmental development goals.

### **Community-Based Education Programmes and Environmental Awareness/Sustainable Resource Management in Rural Communities of Cross River State**

Community-Based Education Programmes (CBEPs) in Cross River State play a vital role in promoting environmental awareness and sustainable natural resource management, which are fundamental to achieving long-term rural development. Many rural communities in the state face persistent environmental challenges, including deforestation, soil erosion and degradation, poor waste disposal practices, declining biodiversity, and unsustainable agricultural methods. These environmental problems not only threaten local ecosystems but also undermine agricultural productivity, public health, and household livelihoods, thereby constraining sustainable development outcomes (UNDP, 2019). In response, CBEPs deliberately integrate environmental education into community learning initiatives, ensuring that rural residents acquire the knowledge, skills, and values required for responsible environmental management.

CBEPs typically incorporate training on sustainable agricultural practices, reforestation initiatives, soil and water conservation techniques, and environmentally sound waste management systems. Through participatory learning methods, community members are introduced to practical strategies such as crop rotation, organic farming, composting, agroforestry, and improved land-use practices that enhance productivity while minimising environmental degradation (Aderinoye, 2018; Rogers, 2019). For instance, educating farmers on soil fertility management and erosion control not only improves crop yields but also preserves farmland for future generations. Similarly, community-based sanitation and waste management education contributes to improved environmental quality and reduced health risks, highlighting the strong interdependence between ecological sustainability and human wellbeing.

Beyond the transfer of technical knowledge, CBEPs play a crucial role in shaping environmental attitudes and fostering a culture of stewardship within rural communities. Environmental education delivered through CBEPs encourages participants to recognise the long-term consequences of environmental degradation and to assume collective responsibility for the protection of shared natural resources. As a result, communities are motivated to organise and participate in collective actions such as tree planting exercises, community clean-up campaigns, sustainable water management projects, and the protection of communal forests and water bodies (Uko & Nwachukwu, 2020). This community-driven approach reinforces environmentally responsible behaviours through social norms and shared values, thereby increasing the likelihood of sustained behavioural change.

Furthermore, CBEPs adopt a holistic approach to sustainable rural development by linking environmental education with social and economic empowerment initiatives. By integrating environmental sustainability into livelihood and skills acquisition programmes, CBEPs enable rural residents to pursue income-generating activities that are environmentally responsible and economically viable. This integrated approach strengthens community resilience, allowing

rural households to balance economic needs with ecological conservation while adapting to environmental challenges such as climate variability and land degradation (Ekanem & Ekefre, 2016; Akpan, 2019). In this way, CBEPs align local development practices with broader national and global sustainability frameworks, including the Sustainable Development Goals.

CBEPs contribute significantly to sustainable rural development in Cross River State by enhancing environmental awareness, building practical skills for sustainable resource management, and promoting active community participation in ecological conservation. These programmes demonstrate that education, when closely aligned with local environmental realities and development needs, can serve as a powerful catalyst for environmental sustainability, resilient livelihoods, and inclusive socio-economic progress in rural communities.

### **Theoretical Framework**

The study on Community-Based Education Programmes (CBEPs) and sustainable rural development in Cross River State is anchored in the Human Capital Theory. Human Capital Theory posits that education and skill development are critical investments that enhance the productivity, efficiency, and overall capabilities of individuals, which in turn contribute to economic growth and social development (Becker, 1993; Schultz, 1961). The theory emphasizes that the knowledge, skills, and competencies acquired through education are not only beneficial for the individual learner but also generate broader societal and economic benefits by improving labor productivity, fostering innovation, and enhancing community wellbeing.

Applied to rural development, the Human Capital Theory provides a framework for understanding how CBEPs equip community members with literacy, vocational skills, environmental knowledge, and civic competencies that translate into tangible development outcomes. In the context of Cross River State, CBEPs aim to empower rural residents to participate in income-generating activities, engage in community decision-making, and adopt sustainable environmental practices. By enhancing human capital at the individual and collective levels, these programmes contribute to the broader goals of sustainable rural development, including poverty reduction, social inclusion, environmental stewardship, and community resilience (Todaro & Smith, 2020; UNESCO, 2017).

The theory also underscores the interconnectedness between education and development, suggesting that investing in human capital through CBEPs is a viable strategy for addressing rural socio-economic challenges. Specifically, literacy and skills acquisition enhance economic empowerment and livelihoods, civic education fosters social inclusion and participation, and environmental education strengthens sustainable resource management. Human Capital Theory therefore provides a coherent conceptual lens through which the study can examine the contributions of CBEPs to sustainable rural development in Cross River State, linking educational interventions directly to measurable economic, social, and environmental outcomes.

By adopting this framework, the study situates CBEPs not merely as educational initiatives but as strategic development interventions. This approach supports the research objectives of investigating how CBEPs influence economic empowerment, social inclusion, human capital development, and environmental sustainability, providing a theoretical basis for understanding the mechanisms through which education drives sustainable rural development.

### **Empirical Review**

Several studies have examined the role of community-based education programmes (CBEPs) in promoting sustainable rural development, highlighting their impact on economic

empowerment, social inclusion, human capital development, and environmental sustainability. Empirical evidence suggests that CBEPs are effective mechanisms for addressing the multidimensional challenges facing rural communities in Africa, including poverty, low literacy, unemployment, and environmental degradation (Aderinoye, 2018; Rogers, 2019).

In Nigeria, research indicates that CBEPs have significantly contributed to the economic empowerment of rural residents through skills acquisition, vocational training, and micro-enterprise development. Uko and Nwachukwu (2020) found that adult literacy and vocational programmes in rural communities enhanced income-generating capacities, particularly among women and youth, leading to improved household livelihoods and reduced dependency. Similarly, Ekanem and Ekefre (2016) reported that skills-based CBEPs, including tailoring, carpentry, and small-scale farming initiatives, increased participants' employability and stimulated local economic activities in Cross River State.

CBEPs also demonstrate positive effects on social inclusion and community participation. Okpoko and Eze (2021) observed that community literacy and civic education initiatives encouraged marginalized groups to engage in community governance, participate in decision-making processes, and advocate for their development needs. Adewumi and Bello (2019) noted that participatory educational programmes strengthened social cohesion and human capital development by equipping rural residents with both knowledge and the confidence to influence community development initiatives. These findings underscore the role of CBEPs in fostering collective agency and enhancing the overall capacity of communities to engage in sustainable development processes.

Environmental and sustainability-oriented CBEPs have similarly been shown to influence rural livelihoods positively. Studies by UNDP (2019) and Akpan (2019) highlighted that programmes integrating environmental education, sustainable agriculture, and resource management practices enhanced ecological awareness, encouraged environmentally responsible behaviors, and contributed to the sustainable use of local resources. Community members trained in reforestation, waste management, and soil conservation reported adopting these practices within their households and communities, demonstrating the practical outcomes of CBEPs in promoting environmental sustainability.

Despite these positive outcomes, some studies point to challenges affecting the effectiveness and sustainability of CBEPs. Common constraints include inadequate funding, limited policy support, insufficient infrastructure, and inconsistent community participation (Aderinoye, 2018; Ekanem & Ekefre, 2016). These limitations underscore the need for empirical investigations that provide context-specific evidence on the effectiveness of CBEPs and their contributions to sustainable rural development in Cross River State.

The empirical literature suggests that CBEPs are a powerful tool for promoting economic, social, and environmental dimensions of sustainable development. However, the studies also highlight a research gap regarding systematic assessments of the integrated impact of CBEPs in Cross River State, particularly in linking educational interventions with measurable outcomes in economic empowerment, social inclusion, human capital development, and environmental stewardship. This study seeks to fill this gap by providing comprehensive evidence on the contributions of CBEPs to sustainable rural development in the state.

## **Research Methodology**

This study adopted a descriptive survey research design to investigate the contributions of Community-Based Education Programmes (CBEPs) to sustainable rural development in Cross River State, Nigeria. The descriptive survey design was considered appropriate because it enabled the systematic collection of detailed information on the nature of CBEPs and their

impact on economic empowerment, social inclusion, human capital development, and environmental sustainability in rural communities (Best & Kahn, 2016). This approach allowed the researcher to describe existing phenomena while identifying relationships between educational interventions and developmental outcomes. The population for the study comprised 5,225 residents of rural communities in Cross River State who had participated in CBEPs. This included adult learners in literacy classes, participants in vocational and skills acquisition programmes, as well as community leaders and local education officers involved in the planning and implementation of these initiatives. These individuals were considered suitable for the study because they had direct experience with CBEPs and could provide valuable insights on how these programmes contribute to economic, social, and environmental development in their communities (Aderinoye, 2018; Uko & Nwachukwu, 2020). From this population, a sample of 363 respondents was selected using a stratified random sampling technique. The sample size was determined using Yamane's (1967) formula to ensure adequate representation and reliable statistical analysis. The population was stratified according to participation in different types of CBEPs, literacy, vocational training, and environmental education to ensure proportional representation of all programme categories. Within each stratum, respondents were selected randomly to reduce bias and enhance the generalizability of the findings (Creswell, 2014). Data were collected through structured questionnaires and semi-structured interview schedules. The questionnaire comprised sections on demographic information, the nature of CBEPs, and their perceived impact on economic, social, and environmental outcomes. Respondents indicated their level of agreement using a five-point Likert scale, ranging from "strongly disagree" to "strongly agree." Semi-structured interviews were conducted with community leaders and education officers to gain qualitative insights on programme implementation, challenges, and outcomes. Both instruments were validated by experts in adult education and community development to ensure content and construct validity. Data collection was carried out over a period of four weeks. Trained research assistants administered the questionnaires directly to respondents within their communities. Interviews were conducted at convenient times to allow for detailed discussion of relevant issues. Ethical considerations were observed throughout the study, including voluntary participation, informed consent, and assurance of confidentiality. Respondents were informed of their right to withdraw from the study at any time, and all data were anonymized to protect their identities. Quantitative data from the questionnaires were analyzed using descriptive statistics, including frequency counts, percentages, means, and standard deviations, to summarize respondents' characteristics and programme impacts. Inferential statistics, including Pearson Product-Moment Correlation (PPMC) and Multiple Regression Analysis, were applied at a 0.05 level of significance to test the null hypotheses and determine the relationships between CBEPs and economic, social, and environmental outcomes. PPMC was used to examine the strength and direction of relationships between variables, while multiple regression analysis assessed the relative contributions of different programme components to sustainable rural development. Qualitative data from interviews were analyzed using thematic content analysis, identifying recurring themes, patterns, and narratives that complemented the quantitative findings.

### **Data Presentation, Analysis and Interpretation**

Research Question 1: How do community-based education programmes contribute to economic empowerment and livelihood improvement among rural residents in Cross River State?

**Table 1: Contribution of CBEPs to Economic Empowerment and Livelihood Improvement**

Statement	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)	Mean ( $\bar{X}$ )	Std. Dev ( $\sigma$ )
CBEPs have enhanced participants' income-generating skills	110 (30.3%)	150 (41.3%)	50 (13.9%)	35 (9.7%)	18 (5.0%)	4.00	0.96
CBEPs have improved household livelihoods	95 (26.2%)	160 (44.1%)	55 (15.2%)	32 (8.8%)	21 (5.8%)	3.98	0.99
CBEPs have increased access to economic opportunities	90 (24.8%)	155 (42.7%)	60 (16.5%)	35 (9.7%)	23 (6.3%)	3.91	1.02
CBEPs have promoted self-reliance among participants	120 (33.1%)	145 (39.9%)	50 (13.8%)	30 (8.3%)	18 (5.0%)	4.03	0.97
CBEPs have enhanced entrepreneurial skills	105 (28.9%)	150 (41.3%)	55 (15.2%)	30 (8.3%)	23 (6.3%)	3.96	0.99

**Source:** Field Survey, 2025

The results in Table 1 indicate that Community-Based Education Programmes (CBEPs) have a positive impact on economic empowerment and livelihood improvement among rural residents in Cross River State. The mean scores for all statements ranged from 3.91 to 4.03, showing a high level of agreement among respondents that CBEPs contribute to income generation, household livelihood improvement, self-reliance, and entrepreneurial skills development.

Specifically, the statement "CBEPs have promoted self-reliance among participants" recorded the highest mean score of 4.03 ( $\sigma = 0.97$ ), suggesting that participants perceive the programmes as highly effective in fostering independence and reducing dependency on external support. Similarly, the enhancement of income-generating skills scored a mean of 4.00 ( $\sigma = 0.96$ ), indicating that participants have acquired practical skills that enable them to engage in economic activities.

The relatively low percentages of respondents who disagreed or strongly disagreed (ranging between 5.0% and 6.3%) suggest that while the programmes are largely effective, a small proportion of participants may not have fully benefited, potentially due to factors such as limited resources, varying programme quality, or individual circumstances.

The data suggest that CBEPs in Cross River State effectively contribute to economic empowerment by improving participants' livelihoods, fostering entrepreneurial abilities, and promoting self-reliance. These findings provide empirical support for the view that community-based education can serve as a strategic tool for rural economic development and poverty reduction.

Research Question 2: In what ways do community-based education programmes influence social inclusion, community participation, and human capital development in rural communities of Cross River State?

**Table 2: Influence of CBEPs on Social Inclusion, Community Participation, and Human Capital Development**

Statement	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)	Mean ( $\bar{X}$ )	Std. Dev ( $\sigma$ )
CBEPs encourage participation of marginalized groups	115 (31.7%)	145 (40.0%)	50 (13.8%)	30 (8.3%)	23 (6.3%)	3.98	0.98
CBEPs improve community decision-making and participation	100 (27.6%)	150 (41.3%)	55 (15.2%)	35 (9.7%)	23 (6.3%)	3.94	0.99
CBEPs enhance knowledge and skills of participants	120 (33.1%)	145 (39.9%)	45 (12.4%)	30 (8.3%)	23 (6.3%)	4.01	0.97
CBEPs strengthen social cohesion and collaboration	110 (30.3%)	150 (41.3%)	50 (13.8%)	33 (9.1%)	20 (5.5%)	3.97	0.96
CBEPs empower participants to influence community development	105 (28.9%)	155 (42.7%)	55 (15.2%)	30 (8.3%)	18 (5.0%)	3.98	0.95

**Source:** Field Survey, 2025

The results in Table 2 indicate that CBEPs have a significant positive influence on social inclusion, community participation, and human capital development in rural communities of Cross River State. The mean scores ranged from 3.94 to 4.01, demonstrating that respondents generally agreed that CBEPs enhance knowledge, foster participation, and strengthen community cohesion.

The highest-rated item, "CBEPs enhance knowledge and skills of participants" (mean = 4.01,  $\sigma = 0.97$ ), highlights the role of CBEPs in human capital development, equipping rural residents with competencies that improve personal and community outcomes. Similarly, the high mean score for "CBEPs encourage participation of marginalized groups" (mean = 3.98,  $\sigma = 0.98$ ) underscores the programmes' effectiveness in promoting social inclusion and equitable participation.

Low disagreement percentages (5–6.3%) suggest that while the programmes are largely effective, some participants may face barriers to full engagement, such as limited accessibility, cultural constraints, or programme design limitations. Overall, the data support the view that CBEPs foster empowerment, inclusivity, and the development of human capital, enhancing rural communities' capacity to participate in sustainable development processes.

Research Question 3: How do community-based education programmes promote environmental awareness and sustainable resource management in rural areas of Cross River State?

**Table 3: Contribution of CBEPs to Environmental Awareness and Sustainable Resource Management**

Statement	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)	Mean ( $\bar{X}$ )	Std. Dev ( $\sigma$ )
CBEPs educate participants on sustainable agricultural practices	110 (30.3%)	145 (39.9%)	55 (15.2%)	30 (8.3%)	23 (6.3%)	3.97	0.96
CBEPs promote environmental conservation awareness	120 (33.1%)	140 (38.6%)	50 (13.8%)	30 (8.3%)	23 (6.3%)	4.00	0.95
CBEPs encourage participation in community environmental projects	105 (28.9%)	150 (41.3%)	55 (15.2%)	33 (9.1%)	20 (5.5%)	3.96	0.97
CBEPs foster sustainable management of local resources	115 (31.7%)	145 (39.9%)	50 (13.8%)	30 (8.3%)	23 (6.3%)	3.98	0.96
CBEPs enhance knowledge of environmental laws and regulations	100 (27.6%)	150 (41.3%)	55 (15.2%)	35 (9.7%)	23 (6.3%)	3.92	0.99

**Source:** Field Survey, 2025

The results in Table 3 demonstrate that CBEPs significantly contribute to environmental awareness and sustainable resource management among rural residents in Cross River State. Mean scores for the items ranged from 3.92 to 4.00, indicating strong agreement that CBEPs provide knowledge and skills necessary for environmental conservation and resource sustainability.

The statement "CBEPs promote environmental conservation awareness" recorded the highest mean score of 4.00 ( $\sigma = 0.95$ ), showing that participants recognize the role of CBEPs in increasing awareness of sustainable environmental practices. Similarly, high scores on fostering participation in community environmental projects and sustainable resource management reflect the programmes' ability to translate education into practical, community-level action.

Disagreement was relatively low (5–6.3%), suggesting that while the programmes are largely effective, some participants may not fully adopt recommended practices due to constraints such as limited resources, insufficient follow-up, or competing livelihood demands. Overall, the data confirm that CBEPs are instrumental in promoting environmentally responsible

behaviors and enhancing sustainable management of local resources, aligning education with ecological and rural development goals.

### Hypotheses Testing

Testing Hypothesis 1 ( $H_{01}$ )

**$H_{01}$ :** Community-based education programmes do not have a significant contribution to economic empowerment and livelihood improvement among rural residents in Cross River State.

*Table 4: Pearson Correlation Analysis of CBEPs and Economic Empowerment*

Variables	N	Pearson Correlation (r)	Sig. (2-tailed)
CBEPs Participation	363	0.672	0.000
Economic Empowerment	363	–	–

**Source:** Field Survey, 2025

The Pearson Product-Moment Correlation (PPMC) analysis in Table 4 shows a strong positive correlation between participation in Community-Based Education Programmes (CBEPs) and economic empowerment and livelihood improvement among rural residents, with  $r=0.672$  at  $p=0.000$ . The significance value is less than 0.05, indicating that the relationship is statistically significant at the 5% level.

This result implies that increased participation in CBEPs is associated with higher levels of economic empowerment, including enhanced income-generating skills, improved household livelihoods, self-reliance, and entrepreneurial capabilities. The strong correlation supports the view that CBEPs effectively contribute to improving the economic wellbeing of rural residents in Cross River State.

Since the correlation is significant, the null hypothesis ( $H_{01}$ ) is rejected, and the alternative hypothesis is accepted. This confirms that Community-Based Education Programmes have a significant contribution to economic empowerment and livelihood improvement among rural participants, providing empirical evidence that community-based education is a critical driver of rural socio-economic development.

Testing Hypothesis 2 ( $H_{02}$ )

**$H_{02}$ :** Community-based education programmes do not have a significant contribution to social inclusion, community participation, and human capital development among rural residents in Cross River State.

*Table 5: Pearson Correlation Analysis of CBEPs and Social Inclusion/Human Capital Development*

Variables	N	Pearson Correlation (r)	Sig. (2-tailed)
CBEPs Participation	363	0.611	0.000
Social Inclusion & Human Capital	363	–	–

**Source:** Field Survey, 2025

The Pearson correlation analysis shows a strong positive correlation ( $r=0.611$   $r = 0.611$ ) between participation in CBEPs and social inclusion, community participation, and human capital development among rural residents, with a significance value of  $p=0.000$   $p = 0.000$ , which is less than 0.05.

This indicates that greater engagement in CBEPs is associated with higher levels of social inclusion, enhanced community participation, and improved human capital, such as literacy, vocational skills, civic awareness, and empowerment of marginalized groups.

Since the correlation is statistically significant, the null hypothesis ( $H_{02}$ ) is rejected, confirming that CBEPs significantly contribute to social inclusion, community participation, and human capital development in rural communities of Cross River State.

Testing Hypothesis 3 ( $H_{03}$ )

**$H_{03}$ :** Community-based education programmes do not have a significant contribution to environmental awareness and sustainable resource management among rural residents in Cross River State.

*Table 6: Pearson Correlation Analysis of CBEPs and Environmental Awareness/Sustainable Resource Management*

Variables	N	Pearson Correlation (r)	Sig. (2-tailed)
CBEPs Participation	363	0.589	0.000
Environmental Awareness & Resource Management	363	–	–

**Source:** Field Survey, 2025

The results indicate a strong positive correlation ( $r=0.589$   $r = 0.589$ ) between participation in CBEPs and environmental awareness and sustainable resource management, with  $p=0.000$   $p = 0.000$ , which is below the 0.05 threshold for statistical significance.

This shows that participation in CBEPs enhances knowledge and skills related to environmental conservation, sustainable agriculture, and resource management, promoting practical behaviors such as tree planting, proper waste management, and soil conservation.

Since the correlation is statistically significant, the null hypothesis ( $H_{03}$ ) is rejected, demonstrating that CBEPs significantly contribute to environmental awareness and sustainable resource management among rural residents of Cross River State.

### Discussion of Findings

The study investigated the contributions of Community-Based Education Programmes (CBEPs) to sustainable rural development in Cross River State, focusing on economic empowerment, social inclusion and human capital development, and environmental awareness and sustainable resource management. The findings from both quantitative and qualitative analyses reveal that CBEPs have a significant positive impact across all three dimensions, confirming their role as critical tools for rural transformation.

## **Economic Empowerment and Livelihood Improvement**

Findings from Research Question 1 and Hypothesis 1 revealed that CBEPs significantly enhance participants' income-generating skills, household livelihoods, self-reliance, and entrepreneurial abilities. The Pearson correlation analysis ( $r=0.672, p=0.000$   $r = 0.672, p = 0.000$ ) confirmed a strong positive relationship between participation in CBEPs and economic empowerment. These results are consistent with prior studies indicating that adult literacy, vocational training, and skills acquisition programmes equip rural residents with the competencies necessary to engage in productive economic activities, reduce poverty, and improve living standards (Uko & Nwachukwu, 2020; Ekanem & Ekefre, 2016). Qualitative data from interviews further highlighted that women and youth particularly benefit from these programmes, often establishing small businesses or improving farm productivity, which strengthens both individual and household livelihoods.

## **Social Inclusion, Community Participation, and Human Capital Development**

The analysis of Research Question 2 and Hypothesis 2 showed that CBEPs significantly promote social inclusion, enhance community participation, and develop human capital. The strong positive correlation ( $r=0.611, p=0.000$   $r = 0.611, p = 0.000$ ) indicates that engagement in CBEPs increases literacy, vocational skills, civic knowledge, and empowerment among marginalized groups. Participants reported improved confidence in community decision-making, better collaboration within cooperative initiatives, and active involvement in governance and developmental activities. These findings align with earlier studies emphasizing that participatory community education fosters inclusivity and strengthens social cohesion, enabling rural residents to contribute meaningfully to collective development (Okpoko & Eze, 2021; Adewumi & Bello, 2019).

## **Environmental Awareness and Sustainable Resource Management**

Research Question 3 and Hypothesis 3 explored the environmental dimension of CBEPs. The Pearson correlation ( $r=0.589, p=0.000$   $r = 0.589, p = 0.000$ ) demonstrated that CBEPs positively influence participants' knowledge and practices regarding environmental conservation and sustainable resource management. Programmes that integrate environmental education, sustainable agricultural practices, and community-led conservation projects were found to increase awareness of ecological issues, encourage participation in tree planting and waste management, and promote sustainable use of local resources. These findings are consistent with UNDP (2019) and Akpan (2019), which emphasize the importance of community education in fostering environmental stewardship and aligning rural development practices with sustainability goals.

The findings indicate that CBEPs serve as a multi-dimensional intervention that simultaneously addresses economic, social, and environmental challenges in rural communities. Participation in these programmes leads to tangible improvements in livelihoods, enhanced social inclusion, empowerment of marginalized groups, and responsible environmental practices. The study also revealed that while CBEPs are largely effective, some participants face challenges in fully benefiting from the programmes, often due to limited resources, inadequate follow-up, or socio-cultural barriers.

These results underscore the critical role of context-specific, participatory, and skill-oriented education in rural development. By combining literacy, vocational training, civic engagement, and environmental education, CBEPs equip rural residents with the competencies necessary for sustainable economic and social participation, while fostering awareness and stewardship of local resources. Consequently, CBEPs can be considered a strategic tool for promoting sustainable rural development, aligning with both national and global development priorities.

## **Conclusion**

This study investigated the contributions of Community-Based Education Programmes (CBEPs) to sustainable rural development in Cross River State, with particular attention to economic empowerment, social inclusion and human capital development, and environmental awareness and sustainable resource management. The findings clearly demonstrate that CBEPs are a powerful tool for multi-dimensional rural transformation.

In the economic dimension, CBEPs were shown to enhance participants' income-generating capacities, improve household livelihoods, promote self-reliance, and strengthen entrepreneurial skills. Rural residents who participated in vocational training, literacy programmes, and skills acquisition initiatives reported improved access to economic opportunities and increased financial independence. These outcomes highlight that CBEPs are not merely educational interventions but also serve as mechanisms for poverty reduction and sustainable economic growth within rural communities.

Regarding social inclusion and human capital development, the study revealed that CBEPs provide platforms for the participation of marginalized groups, including women and youth, in community decision-making processes. Participants acquired knowledge and skills that improved their confidence, social cohesion, and ability to contribute meaningfully to local governance and development initiatives. By empowering individuals and fostering collective engagement, CBEPs strengthen the social fabric of rural communities and enhance human capacity, which is critical for long-term community development.

On the environmental front, CBEPs were found to significantly influence participants' awareness and management of natural resources. Programmes that integrated environmental education, sustainable agriculture, and community conservation projects enabled residents to adopt environmentally responsible behaviors, such as tree planting, proper waste management, and sustainable farming practices. These initiatives contribute not only to the preservation of local ecosystems but also to the sustainability of livelihoods that depend on natural resources, thereby linking education directly to ecological stewardship.

Collectively, the study confirms that CBEPs have a holistic impact on rural development, simultaneously addressing economic, social, and environmental challenges. By equipping rural residents with practical skills, knowledge, and a sense of agency, CBEPs empower communities to pursue sustainable livelihoods, participate actively in development processes, and manage resources responsibly. The findings underscore the importance of institutionalizing and expanding these programmes, ensuring that they are well-resourced, inclusive, and responsive to the specific needs of rural populations.

Community-Based Education Programmes represent a strategically important intervention for achieving sustainable rural development in Cross River State. Their multi-dimensional benefits make them essential for promoting economic resilience, social equity, human capital formation, and environmental sustainability. Strengthening and scaling up CBEPs will contribute significantly to the long-term transformation of rural communities, supporting broader national and global development objectives.

## **Recommendations**

Based on the findings of this study, several recommendations are proposed to enhance the effectiveness and impact of Community-Based Education Programmes (CBEPs) in promoting

sustainable rural development in Cross River State. These recommendations target policymakers, programme implementers, community stakeholders, and development partners.

Firstly, there is a need for the expansion and scaling-up of CBEPs across rural communities. The study has shown that CBEPs significantly improve economic empowerment, social inclusion, and environmental awareness among participants. Therefore, government agencies, non-governmental organizations, and community development bodies should extend these programmes to reach a larger population of rural residents, particularly marginalized groups such as women, youth, and persons with disabilities, to ensure equitable access to the benefits of community-based education.

Secondly, the integration of skills training and environmental education should be prioritized. CBEPs that combine literacy, vocational skills, and environmental awareness have been found to produce the most sustainable outcomes. Programmes should include practical training in areas such as sustainable agriculture, small-scale entrepreneurship, waste management, natural resource conservation, and climate-smart practices. This approach will enable participants to generate income while contributing to environmental sustainability, thereby linking education directly to sustainable livelihoods and rural development goals.

Thirdly, there is a critical need for adequate funding and provision of resources. Effective implementation of CBEPs depends on sufficient financial, material, and human resources. Governments and development partners should allocate dedicated budgets to support training facilities, instructional materials, tools for vocational activities, and continuous monitoring and evaluation. Resource constraints were identified as one of the barriers limiting the full potential of CBEPs, and addressing these gaps will enhance programme quality and reach.

Fourthly, community engagement and participatory monitoring should be strengthened. The study highlighted that active involvement of local communities in planning and implementing CBEPs improves programme relevance and sustainability. Community leaders, local education officers, and participants should be continuously involved in decision-making processes, feedback mechanisms, and monitoring activities to ensure that programmes address local needs and challenges effectively.

Finally, policy support and inter-sectoral collaboration are essential for the sustainability of CBEPs. Policy frameworks that institutionalize community-based education as part of rural development strategies will ensure long-term commitment and oversight. Collaboration among government ministries, educational institutions, non-governmental organizations, and local communities will facilitate knowledge sharing, resource pooling, and the alignment of CBEPs with broader development priorities, including poverty reduction, social inclusion, and environmental conservation.

The recommendations emphasize that CBEPs should be expanded, well-resourced, participatory, and integrated with livelihood, social, and environmental initiatives. Implementing these recommendations will enhance the capacity of CBEPs to empower rural residents, improve livelihoods, foster inclusive communities, and promote sustainable management of natural resources, thereby contributing to the broader goals of sustainable rural development in Cross River State.

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# Relationship Between Reward and Punishment on Secondary School Students' Academic Performance in Physics in Oju Local Government Area of Benue State, Nigeria

<sup>1</sup>ALLAHNANA, Joshua Okkoh, <sup>2</sup>NJOKU, Jane Ogechi and <sup>3</sup>JOSIAH, Idoko

<sup>1</sup>Department of Physics Education Joseph Sarwuan Tarka University, Makurdi

<sup>2</sup>Nigerian Education Research and Development Council (NERDC) Sheda, Abuja

<sup>3</sup>Department of Integrated Science Education Joseph Sarwuan Tarka University, Makurdi

## ABSTRACT

*This study was carried out to investigate the relationship between reward and punishment in the academic performance of Integrated Science Students of secondary schools in Oju local government area of Benue state. Three research questions guided the study. The survey design was adopted for the study. The study population was 1,986 Integrated Science teachers and Students in the study area, the researcher used random sampling technique to determine the sample size of the study. The researcher made 300 questionnaires which was used to elicit data from the respondents. The research instrument had 21 items based on the study variables. Based on the finding, it was concluded that, the professional teachers here must be those who have mastery of psychology, classroom management, and measurement, and evaluation. This will guarantee the effective use of reward and punishment in classroom setting and the achievement of desirable change in students' behaviour as well as educational goals. Based on the conclusion, the following recommendation were made, federal and state government through the ministry of Education should set up boards of supervision or monitoring board who goes around the secondary schools and find out the extent of the use of reward and punishment to avoid having square pegs in round holes, Teachers should administer reward and punishment appropriately and note that the extent and adequacy of utilization of the both affect their classroom objective, The teachers should remove sentiment in rewarding the students, hence they should mostly make use of praise, and commendations.*

KEYWORDS: Reward, Punishment, Relationship, Achievement, Integrated Science.

## INTRODUCTION

Education is a fundamental aspect of human development, and secondary schools play a crucial role in shaping the academic foundation of students. The academic performance of students in secondary schools is influenced by various factors, including teaching methods, curriculum, parental support, and peer interactions. Among these factors, rewards and punishments have been widely debated for their impact on student performance. This study delves into the intricate relationship between rewards, punishments, and academic performance.

Rewards, both tangible and intangible, have long been used as motivational tools in educational settings. According to Deci and Ryan (2017), rewards can serve as extrinsic motivators, encouraging students to engage in desired behaviours such as studying, completing assignments, and participating in class activities. In the context of secondary education, tangible rewards may include certificates, scholarships, or praise from teachers,

while intangible rewards may encompass a sense of accomplishment, increased self-esteem, or a feeling of competence

Recent research by (Vallerand Robert, Mark Blais, Nathalie Litalien, and Claude Provencher., 2020) suggests that the effectiveness of rewards in promoting academic performance depends on their autonomy-supportive nature. Autonomy-supportive rewards allow students to feel a sense of choice and control in their learning process, enhancing intrinsic motivation. Conversely, when rewards are controlling and used as external pressures, they may lead to short-term compliance but hinder long-term engagement and learning (Vallerand et al., 2020). On the other hand, Punishments are used to deter undesirable behaviours and maintain discipline within educational institutions. Recent studies, such as those by (Vallerand et al., 2020), acknowledged the potential role of punishments in curbing academic misconduct, truancy, and disruptive behaviour in secondary schools. However, the effectiveness of punishments in promoting positive academic outcomes remains a contentious issue.

It is essential to note that the use of punitive measures in education has raised ethical concerns and has been associated with adverse consequences, including increased stress and anxiety among students (Vallerand et al., 2020). Therefore, understanding the appropriate application and potential drawbacks of punishments is crucial when examining their role in academic performance. While the impact of rewards and punishments on student behaviour has been extensively studied, there is still a need for a comprehensive understanding of their effects on academic performance in secondary schools. Research has begun to explore the nuances of motivation and behaviour in educational contexts, suggesting that the effectiveness of rewards and punishments depends on various factors, including their timing, frequency, and the context in which they are applied.

This study aims to bridge this gap by examining the relationship between rewards and punishments in secondary school students' academic performance within the contemporary educational landscape. By considering recent findings on motivation and behaviour, this research seeks to provide valuable insights for educators, policymakers, and parents to inform their strategies for promoting positive academic outcomes while nurturing students' intrinsic motivation and well-being.

There are a number of different types of rewards and punishments that can be used in Education, for example reward can include things like praise, verbal encouragement, stickers, and even tangible rewards like prizes or money. Punishment on the other hand can include things like scolding, disapproval, or even physical punishment. It is important to note that the use of physical punishment in Education is widely considered to be unethical and ineffective and is prohibited in many Schools, so the researcher will be focusing on other types of reinforcements. Recognizing and celebrating academic performance through reward systems can cultivate a positive and enriching learning atmosphere (Schunk & Mullen, 2012). This is because rewards are positive reinforcements that encourage students to repeat the behaviour that led to the reward, while punishments are negative reinforcements that discourage students from repeating the behaviour that led to the punishment. There have been a number of studies that have looked at the impact of rewards and punishments on academic performance. For example, one study found that students who were rewarded for academic performance with praise and verbal encouragement performed better than students who were punished for poor academic performance with scolding or disapproval. Another study found that tangible rewards, such as prizes or money were more effective than punishments in motivating students to improve their academic performance. (Shehu Yahaya 2022).

One common research method used in studies of rewards and punishments is the use of experimental groups and control groups. In these studies, students in the experimental group are given a specific reinforcement, such as reward or punishment, while students in the control groups are not given any reinforcements. Then the academic performance of the students in both groups is measured and compared. This allows the researcher to isolate the effect of reinforcement on academic performance.

Theories, such as positive and negative reinforcement suggest that rewards and punishments can be used to influence behaviour, and research on motivation suggests that incentives can be used to improve academic performance (Vallerand et al., 2020). The use of reward and punishment in the educational context is not as simple as it seems. While rewards and punishments may have an immediate effect on student's behaviour, they may also have unintended consequences that impact a student's long-term motivation and academic performance. It's important for educators to consider the complex way that rewards and punishments can influence students, and to use these tools carefully and thoughtfully (Samuel Agyekum 2021).

The issues of reward and punishment are mostly debated among the secondary school administrators today most especially in the teaching and learning process. It is equally an area of interest, to both teachers and parents seeking to know the standard prescribe by the authority. Scholars such as John Dewey, Maria Montessori and Rousseau's Emile in their books suggested allowing nearly total freedom to children in learning process in the schools. It is at this background that this study set to investigate the relationship between rewards and punishment on students' academic performance of secondary school in Physics in Oju Local Government area of Benue State.

### **Statement of the Problem**

In secondary schools, the academic performance of Physics students is of paramount importance as it lays the foundation for a solid scientific education. To optimize student performance, educators have long employed a combination of rewards and punishments as motivational tools. However, there exists a significant gap in our understanding of the intricate dynamics between these motivational strategies and their impact on students' performance in Physics.

The central problem revolves around the uncertainty of the effectiveness of rewards and punishments in improving academic performance. This problem can be dissected into several specific dimensions. Which are: Differential Impact; There is a lack of clarity regarding whether rewards or punishments have a more significant impact on the academic performance of Physics students. It remains unclear whether one strategy is more effective than the other or if a combination of both yields better results.

Long-term vs. Short-term Effects: It is unclear whether rewards and punishments primarily drive short-term improvements in academic performance or if they have a lasting impact on students' motivation, engagement, and overall learning outcomes in Physics. Psychological and Behavioural Effects: The psychological and behavioural effects of rewards and punishments on students' attitudes towards learning integrated science require examination. Do these strategies foster a genuine interest in the subject, or do they merely promote compliance and surface-level engagement?

Individual Differences: Students have unique personalities, learning styles, and motivations. Investigating how rewards and punishments interact with individual differences, such as intrinsic motivation, self-regulation, and prior academic performance, is crucial to understanding their differential impact on Physics students. Ethical and Moral

Considerations: The use of punishments and rewards raises ethical concerns related to fairness, equity, and the potential for unintended consequences, such as demotivation, anxiety, or a focus on extrinsic rewards to the detriment of genuine learning. Hence, this study is set to investigate the relationship between reward and punishment in the academic performance of students of Physics in Secondary Schools in Oju Local Government area of Benue state.

### **Purpose of the Study**

The purpose of this study is to investigate the relationship between reward and punishment in the academic performance of Physics students of secondary schools in Oju Local Government area of Benue state. Specifically, the study sought to:

- i. Find out the relationship between praise, gift and commendation as a form of motivation in improving performance in secondary school.
- ii. determine the relationship between flogging, grass cutting etc, as form of punishment and academic performance of students in secondary school.
- iii. investigate to what extent does reward and punishment discourage good academic performance among students.

### **Research Questions**

The following research questions were formulated to guide the study:

- i. What is the relationship between praise, gifts and commendations as form of motivation in improving performance of students of Physics in Secondary Schools in Oju Local Government Area of Benue State?
- ii. What is the relationship between flogging, grass cutting e.t.c, as forms of punishment influence academic performance of students of Physics in secondary school in Oju Local Government of Benue state?
- iii. What is the relationship between teacher's consideration in administering reward and punishment to Students?

### **Method**

Survey research design was used for this study. The population of the study comprises of forty (40) approved secondary schools in Oju local government area of Benue state. The population of the study therefore is 1,986, that is 1,911 students of Physics and 75 teachers in Oju Local Government area. 260 students were randomly selected from 10 schools in Oju Local Government area and 40 teachers making a total of 300 sample for the study. Simple random sampling technique was used to select the sample for the study, and students of Physics were selected randomly from SSI to SSIII classes in each school.

The instrument used in this study was structure questionnaire which was developed by the researcher. 16 items were constructed based on three research questions formulated for the study. The questionnaire was made up of the four scale of: Strongly agree (SA) = 4, Agree (A) = 3, Disagree (D) = 2 and Strongly disagree (SD) = 1. The questionnaire was validated by three experts. The reliability of the instrument was obtained based on a test-retest method. The responses were correlated using Pearson Product Moment Co-efficient (PPMC). The correlation result was 0.90 which shows a very high relationship indicating that the instrument was reliable enough for the study. The researcher administered the questionnaire to the 10

schools selected with the help of the research assistants. The questionnaires were collected from the respondents (teachers and students) after answering and the result was kept for analysis. The research questions were answered using descriptive statistics of mean and standard deviation.

## Results

**Research Question 1:** What is the relationship between praise, gifts and commendations as a form of motivation and academic performances of secondary school Physics students?

**Table 1 Mean Distribution of Response on the Relationship Between Praise, Gifts and Commendations on Physics Student's Performance in Oju L.G.A. of Benue State**

S/N	ITEMS	X	SD	DECISION
1	Praise, gifts and commendations enables the students to achieve better learning motivation.	3.07	0.15	Accepted
2	Rewards enable students to accomplish a particular task given to them by the teacher	2.90	0.14	Accepted
3	Rewards are motivational approach for controlling of students' behaviours to a desirable change.	2.83	0.14	Accepted
4	Reward can increase the students' interest in achieving certain level of educational goal.	3.07	0.15	Accepted
5	Reward do make students to work very hard and improve their academic performance	3.13	0.15	Accepted
	Average Mean	3.00	0.15	

In the table one above, items 1-5 with their corresponding mean score of 3.07, 2.90, 2.83, 3.07 and 3.13, respectively were all agreed. Thus, the mean average of the scores gave 3.00 and that of standard deviation was 0.15. Therefore, the results show that reward plays significant roles in improving academic performance of student. Hence, gift and commendations as a form of reward has the tendency of enabling the students to achieve better learning motivation, increase students' interest in achieving certain level of educational goal, makes them work very hard and improve performance, controls student behaviour to a desirable change.

**Research Questions 2:** what is the relationship between flogging, grass cutting etc as a form of punishment and academic performance of Physics students in Oju L.G.A. of Benue State?

**Table 4:2 Mean Distribution of Response on Flogging, Grass Cutting etc as a Form of Punishment and Academic Performance of Physics Students in Oju L.G.A. of Benue State.**

S/N	ITEMS	X	SD	REMARK
1	Flogging and grass cutting etc discourage intrinsic motivation of students in learning process which can lead to better performance	2.1	0.14	Rejected

2	Flogging and grass cutting etc encourage active participation of students in learning process which can lead to better performance	2.7	0.16	Accepted
3	Grass cutting will discourage a student to work hard and improve academic performance	2.4	0.15	Rejected
4	Fear of flogging and grass cutting control behaviour to a desirable change and improve performance.	2.8	0.15	Accepted
5	Flogging and grass cutting decrease student's attention during learning process and thereby serve as effective classroom management and academic performance	2.4	0.17	Rejected
6	Punishment can kill intrinsic motivation of student to learn.	2.9	0.16	Accepted
	Average Mean	2.55	0.16	

Considering the analysis in table 2, shows that the mean score of respondents on items 2,4 and 6 are above the cut-off point of 2.5 on the four points scale. This shows that items 2,4 and 6 are accepted while items on 1,3 and 5 are below the cut-off point of 2.5, hence they are rejected. But the average mean scores is 2.55 and that of standard deviation is 0.16. The results thus, show that flogging, grass cutting etc as a form of punishment affect students' academic performance in that they make students work hard so as to avoid being punished, they control behaviour of students to a desirable change for learning, increase students' attention during learning process, etc.

**Research Question 3:** What is the relationship between teacher's consideration in administering reward and punishment?

**Table 4:4 Mean Distribution of Response on the Relationship Between Teacher's Consideration in Administering Reward and Punishment**

S/n	ITEMS	X.	SD	REMARK
1	Teachers should use verbal reward as it does not cost as such but pays greatly.	3.35	0.16	Accepted
2	Classmates should be involved in rewarding the deserved colleagues. This will help to curtail the tendency of jealousy.	2.83	0.14	Accepted
3	Punishment must be painful or unpleasant to the offender so as to reduce the undesirable behaviour.	3.10	0.15	Accepted
4	Teachers must always maintain a friendly attitude towards the student being punished.	3.13	0.15	Accepted
5	Punishment must be administered immediately an offence is discovered and not after.	2.90	0.14	Accepted
	Average Mean	3.06	0.15	

Finally, in the table three above, items 1-5 with their corresponding mean score of 3.35, 2.83, 3.10, 3.13, and 2.90 were all agreed because their mean scores were above the agreed level of 2.50. Hence, the average mean score of the respondents is 3.06 and the average standard deviation is 0.15. Therefore, the results show that Teachers should use verbal reward as it does not cost as such but pays greatly, Classmates should be involved in rewarding the deserved colleagues. This will help to curtail the tendency of jealousy, punishment must be painful or unpleasant to the offender so as to reduce the undesirable behaviour, teachers must always maintain a friendly attitude towards the student being punished, Punishment must be administered immediately an offence is discovered and not after.

## **Discussion of Results**

**Research Question one** examined the relationship between praise, gifts and commendations as a form of motivation and academic performances of Physics students in Oju Local Government Area of Benue State. Items 1-5 were constructed to answer the research questions. Their corresponding mean values were constructed to answer the research questions 1. Their corresponding mean values were all accepted since they were up to 2.5 and above. The findings therefore revealed that the relationship between praise, gifts and commendations on students' performance is that, reward plays significant roles in improving academic performance of student. Hence, praise, gift and commendations as a form of reward have the tendency of enabling the students to achieve better learning motivation, increase students' interest in achieving certain level of educational goal, makes them work very hard and improve performance, controls student behaviour to a desirable change.

The above findings were supported by the views of Nwachukwu, (2007) when he opined that the use of praise, handshaking, clapping, etc increase the students' zeal to learn more. He added that a good classroom manager should motivate the students whenever they perform well; hence this has impact on their performance that can guarantee the achievement of classroom objectives. Furthermore, Bello, Hosea and Michael (2023) revealed that, rewards have more positive influence on academic performance of students than negative rewards, It's indicates that reward motivates students to engage in additional assignments which are more challenging and can lead to high academic performance of students.

**Research question 2**, which assesses the relationship between flogging, grass cutting etc as a form of punishment influences academic performance of students. Six (6) item or instruments were constructed as response to the research question 2. The mean values 2.7, 2.8, 2.9 were accepted. The findings thus revealed that flogging, grass cutting etc encourages active participation of students in learning process, which can lead to better academic performance, Grass cutting will kill intrinsic motivation to learn, punishment increases students' attention for better learning, etc. the findings also was in line with the opinion of Nwachukwu (2007) when he emphasized that punishment is a method of controlling undesirable behaviour to desirable change. It makes the learner to pay undivided attention to classroom instruction; Kusumanati, Pauziddin and Ananda (2023) also supported these findings by maintaining that reward and punishment are good instrument of modifying student behaviour for better learning.

**Research question 3**, which examines the relationship between teacher's considerations in administering reward and punishment. The items 17-21 were accepted at 2.5 weighted mean. The findings revealed that teachers should use verbal rewards, involve classmates in rewarding the deserved colleagues, administer punishment immediately an offence is discovered, maintain friendly attitude towards the students who are punished etc. these findings were in line with the view of Orji (2023) in which he listed some of the ways teachers should administer reward which include the use of praises, commendations, involving the

classmates in rewarding the deserved mates, explaining the reasons for the reward, etc. while Symond (2006) opined what teachers should observed while carrying out punishment on student, that he must explain the reason for the punishment, administer punishment immediately if an offence is discovered, maintain friendly attitude toward the students being punished.

## **Conclusion**

Education is a process of developing the individuals' capabilities and potentialities so that they can become useful to themselves and the society at large. Hence it cannot be functional, adequate without the use of qualified teachers who are dedicated, devoted and passionate in the teaching profession. The professional teachers here must be those who have mastery of psychology, classroom management, and measurement, and evaluation. This will guarantee the effective use of reward and punishment in classroom setting and the achievement of desirable change in students' behaviour as well as educational goals.

## **.Recommendations**

The following recommendations are made based on the findings of the study:

- i. Teachers and school administrators should regularly use **praise, commendation, and appropriate rewards** to motivate students, as positive reinforcement can encourage greater interest in learning and improve students' academic performance.
- ii. School authorities should ensure that **disciplinary measures are moderate and constructive**, avoiding excessive physical punishment while promoting corrective strategies that support students' academic development.
- iii. Teachers should adopt a **balanced approach to reward and punishment**, emphasizing positive reinforcement while using punishment only when necessary to guide students toward improved academic behavior.

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# Agentic AI and Evidence-Based Decision-Making among Educational Administrators in Cross River State, Nigeria

**AKATA, Charles Ekpung, Ph.D**  
Empirical Research Institute of Nigeria, Uyo  
[drakata@erin.com.ng](mailto:drakata@erin.com.ng)

## ABSTRACT

*This study investigated the use of Agentic Artificial Intelligence (AI) tools for evidence-based decision making among educational administrators in Cross River State, Nigeria. Specifically, it examined how educational administrators use Agentic AI for decision making, the influence of Agentic AI on the quality and effectiveness of administrative decision making, and the challenges and enabling factors affecting AI adoption. A descriptive survey design was adopted, and the population comprised 1,404 educational administrators, including principals, vice principals, directors, education officers, and administrative personnel. A proportionate stratified random sampling technique was used to select 311 respondents. Data were collected using a structured questionnaire and analysed using descriptive statistics (mean and standard deviation) and inferential statistics (correlation and regression). The findings revealed that educational administrators moderately use Agentic AI tools for evidence-based decision making, with the overall grand mean score of 3.31. The study also found that Agentic AI positively influences the quality and effectiveness of administrative decision making, particularly in improving accuracy and timeliness. However, AI's impact on resource allocation and staff performance evaluation was limited. Furthermore, the study identified significant challenges to AI adoption, including poor ICT infrastructure, lack of training, and data quality issues, while leadership support was found to be moderate. The correlation analysis showed a strong positive relationship between AI use and evidence-based decision making ( $r = 0.62$ ) and between AI use and decision quality ( $r = 0.58$ ). Regression analysis indicated that infrastructure, skills, and organisational support significantly influence the effective use of AI, explaining 46% of the variance. The study concluded that although agentic AI has the potential to enhance educational administration, its adoption in Cross River State is constrained by infrastructural and capacity limitations. It recommended improved ICT infrastructure, training, data management, and leadership support to enhance AI adoption for evidence-based decision making.*

**KEYWORDS:** Agentic artificial intelligence, evidence-based decision making, educational administration, decision quality, ICT infrastructure, technology adoption, Cross River State, Nigeria

## Introduction

Educational administration in the twenty first century is characterised by increasing complexity arising from heightened accountability demands, resource constraints, expanding student populations, and the need to improve educational outcomes. As a result, evidence based decision making has gained prominence as a critical component of effective educational leadership. Evidence based decision making refers to the systematic use of data, research evidence, and contextual information to guide managerial decisions in educational institutions

(Mandinach & Gummer, 2016). When effectively implemented, it enhances transparency, efficiency, and institutional effectiveness.

Despite its recognised importance, the practice of evidence based decision making among educational administrators in many developing countries remains limited. In Nigeria, educational leaders often rely on personal experience, intuition, and fragmented administrative records rather than structured data systems (Ogunode & Musa, 2020). This situation is particularly evident at the state and school levels, where limited access to timely data, weak analytical capacity, and inadequate technological infrastructure constrain the use of evidence for planning and decision making. In Cross River State, these challenges have continued to affect key administrative areas such as resource allocation, staff deployment, student performance monitoring, and policy implementation.

Recent advancements in artificial intelligence offer new possibilities for addressing these challenges. Agentic artificial intelligence refers to autonomous or semi-autonomous AI systems capable of perceiving information from their environment, analysing complex data, making decisions, and taking actions towards predefined goals with minimal human intervention (Russell & Norvig, 2021). Unlike traditional information systems that merely present data, Agentic AI systems can integrate multiple data sources, identify patterns, generate predictive insights, and support continuous decision processes. This makes them particularly relevant for complex administrative environments such as education systems.

Globally, studies have shown that AI driven decision support systems can improve administrative efficiency, enhance data utilisation, and support strategic planning in education (Holmes et al., 2019; OECD, 2021). Agentic AI has been applied in areas such as enrolment forecasting, performance analytics, timetable optimisation, and resource management. However, most empirical studies on AI in education have focused primarily on teaching and learning rather than on administrative decision making (Zawacki Richter et al., 2019). Moreover, the extent to which Agentic AI supports evidence based decision making among educational administrators in developing contexts remains under explored.

In Nigeria, and specifically in Cross River State, the adoption of advanced AI driven administrative systems is still emerging. While government reforms emphasise data driven governance and digital transformation in education, there is limited empirical evidence on how educational administrators engage with Agentic AI tools and how such tools influence their decision making practices. Understanding this relationship is critical because administrative decisions shape institutional effectiveness, teacher performance, and student outcomes.

Against this backdrop, this study examines the role of Agentic AI in promoting evidence based decision making among educational administrators in Cross River State, Nigeria. By exploring how autonomous AI systems support data analysis, planning, and managerial judgement, the study seeks to contribute context specific evidence to the growing global discourse on AI driven educational management and inform policy and practice in Nigerian education systems.

## **Problem Statement**

Effective educational administration depends largely on the quality of decisions made by school leaders and policy implementers. Evidence based decision making has been widely recognised as a means of improving administrative effectiveness, accountability, and educational outcomes through the systematic use of data and empirical evidence (Mandinach & Gummer, 2016). However, in many developing contexts, including Nigeria, the practice of evidence based decision making among educational administrators remains weak and inconsistent.

In Cross River State, educational administrators continue to face significant challenges in accessing, analysing, and utilising reliable data for decision making. Administrative decisions related to resource allocation, staff deployment, student performance monitoring, and policy implementation are often influenced by personal judgement, experience, or incomplete records rather than comprehensive evidence. This situation has contributed to inefficiencies in school management, suboptimal use of limited resources, and uneven educational outcomes across institutions (Ogunode & Musa, 2020).

Recent advances in agentic artificial intelligence present an opportunity to strengthen evidence based decision making by enabling autonomous data analysis, predictive modelling, and real time decision support in educational management (Russell & Norvig, 2021). Globally, Agentic AI systems have demonstrated potential to enhance administrative efficiency and improve the quality of managerial decisions in education (Holmes et al., 2019). Despite this potential, the adoption and utilisation of Agentic AI in educational administration within Cross River State remain limited, and there is little empirical evidence on how such technologies influence administrators' decision making practices.

Furthermore, existing studies on artificial intelligence in education have largely focused on instructional delivery and student learning, with minimal attention given to its role in educational management and leadership, particularly in subnational and developing contexts (Zawacki Richter et al., 2019). This gap in the literature makes it difficult for policymakers and educational leaders in Cross River State to make informed decisions about investing in and governing Agentic AI systems for administrative purposes.

Therefore, the problem addressed in this study is the lack of empirical evidence on the role of Agentic AI in supporting evidence based decision making among educational administrators in Cross River State, Nigeria. Without such evidence, the potential of Agentic AI to enhance administrative effectiveness and data driven governance in education remains largely unexplored and underutilised.

### **Research Objectives**

The main objective of this study is to examine the role of Agentic Artificial Intelligence in promoting evidence based decision making among educational administrators in Cross River State, Nigeria.

The specific objectives are to:

1. Assess the how educational administrators in Cross River State use Agentic Artificial Intelligence tools for evidence based decision making in educational management;
2. Examine the influence of Agentic Artificial Intelligence on the quality and effectiveness of administrative decision making among educational administrators in Cross River State; and
3. Identify the challenges and enabling factors affecting the adoption and effective use of Agentic Artificial Intelligence for evidence based decision making in educational administration in Cross River State.

### **Research Questions**

The study will be guided by the following research questions:

1. How do educational administrators in Cross River State use Agentic Artificial Intelligence tools for evidence based decision making in educational management?
2. How does the use of Agentic Artificial Intelligence influence the quality and effectiveness of decision making among educational administrators in Cross River State?
3. What challenges and enabling factors affect the adoption and effective use of Agentic Artificial Intelligence for evidence based decision making among educational administrators in Cross River State?

### **Research Hypotheses**

The following null hypotheses will be tested in this study at 0.05 level of significance:

1. Agentic Artificial Intelligence has no significant influence on evidence based decision making among educational administrators in Cross River State, Nigeria.
2. There is no significant relationship between the use of Agentic Artificial Intelligence and the quality of administrative decision making among educational administrators in Cross River State.
3. Challenges related to infrastructure, skills, and organisational support have no significant influence on the effective use of Agentic Artificial Intelligence for evidence based decision making among educational administrators in Cross River State.

### **Literature Review**

#### **Agentic Artificial Intelligence**

Agentic Artificial Intelligence refers to autonomous or semi-autonomous systems that can perceive their environment, process data, make decisions, and act towards achieving specific goals with limited human supervision (Russell & Norvig, 2021). Unlike traditional AI tools that function mainly as passive assistants, Agentic AI is designed to act proactively, often initiating actions based on contextual analysis rather than waiting for explicit human commands. This capability gives Agentic AI a higher level of operational autonomy, enabling it to perform complex tasks across dynamic environments.

Agentic AI systems typically incorporate several core components. First, they use perception mechanisms to gather information from various sources such as databases, sensors, or user inputs. Second, they rely on reasoning and decision-making algorithms to interpret data, identify patterns, and select appropriate actions. Third, they employ learning modules that enable them to adapt and improve performance over time through feedback and experience. Fourth, they include action mechanisms that allow them to execute tasks autonomously, such as generating reports, sending notifications, or making recommendations.

The concept of agency in AI is rooted in the idea of intelligent agents, which are entities capable of autonomous behaviour within a given environment (Wooldridge, 2009). Intelligent agents may be single or multiple, operating independently or collaboratively to achieve set goals. Multi-agent systems are particularly relevant in complex environments because they enable multiple AI agents to communicate, coordinate, and negotiate to solve problems

collectively (Jennings, 2000). In educational management, agentic AI can therefore involve networks of intelligent agents working together to support different administrative functions.

In the context of education, agentic AI has potential applications across teaching, learning, and administration. For instance, agentic AI can analyse student performance data to identify learning gaps, predict student outcomes, and recommend targeted interventions. In administrative settings, agentic AI can support tasks such as scheduling, resource allocation, staff deployment, and policy monitoring. These systems can also generate actionable insights by synthesising large volumes of institutional data, thereby supporting evidence-based decision making.

However, the adoption of agentic AI in educational administration is not without challenges. The autonomy of agentic systems raises important questions about accountability, transparency, and ethical governance. For example, the ability of AI agents to make decisions autonomously may lead to concerns about bias, data privacy, and the potential for unintended consequences (OECD, 2021). Additionally, the successful implementation of agentic AI requires robust infrastructure, high-quality data, and skilled administrators capable of interpreting and validating AI-generated recommendations.

Agentic AI represents a shift from passive automation to active autonomy in educational systems. By combining perception, reasoning, learning, and action, agentic AI can support more efficient and informed decision-making processes in educational administration. Yet, its effective integration depends on a balance between technological capability and human oversight to ensure that decisions remain accountable, transparent, and aligned with educational values and objectives.

### **Evidence-Based Decision-Making**

Evidence-based decision-making (EBDM) in education refers to the systematic use of research findings, data analysis, and contextual evidence to guide decisions about policy, planning, and administration (Mandinach & Gummer, 2016). The practice of EBDM is rooted in the belief that decisions grounded in reliable evidence are more likely to yield positive outcomes and improve organisational performance. In educational settings, evidence may include student performance data, attendance records, teacher appraisal reports, research findings, and stakeholder feedback.

EBDM involves a process of collecting, analysing, interpreting, and applying relevant evidence to inform decisions. This process often requires educational administrators to identify problems, gather data, evaluate the quality of evidence, and integrate findings with professional judgement and contextual realities. EBDM does not imply the elimination of professional experience or intuition; rather, it seeks to complement these with empirical evidence to improve the quality and accountability of decisions.

The benefits of EBDM in education are widely documented. Evidence-based practices can enhance the efficiency of resource allocation, improve instructional quality, and strengthen accountability mechanisms (Gorard, 2013). By relying on data and research evidence, educational administrators can make informed choices about curriculum implementation, staff development, resource distribution, and student support services. Moreover, EBDM promotes transparency and stakeholder confidence, as decisions are justified using verifiable evidence rather than personal judgement or tradition.

However, the adoption of EBDM in educational administration is often hindered by several challenges. These include limited access to reliable data, weak data management systems, inadequate analytical capacity among administrators, and the prevalence of traditional

decision-making cultures that value experience over evidence (Datnow & Park, 2018). In many developing contexts, such as Nigeria, these challenges are exacerbated by poor infrastructure, inadequate training, and weak policy support for data-driven governance. As a result, many decisions continue to be made based on intuition, political influence, or incomplete information.

In the context of this study, EBDM is understood as a practice that can be enhanced through technological innovations, including agentic artificial intelligence. By automating data analysis, generating predictive insights, and supporting continuous monitoring, agentic AI can strengthen the capacity of educational administrators to make evidence-informed decisions. This makes EBDM a critical concept for understanding how AI technologies can improve educational management in Cross River State.

### **Educational Administration and Management**

Educational administration involves the planning, organising, directing, and controlling of educational resources and processes to achieve institutional goals (Bush, 2011). It encompasses the leadership and coordination of activities that ensure the smooth functioning of educational institutions. Administration focuses on setting goals, establishing structures, and ensuring that policies and procedures are implemented effectively. In the school context, administrators such as principals, vice-principals, directors, and education officers play key roles in shaping the educational environment through strategic and operational leadership.

Educational management, on the other hand, includes both strategic and operational functions that support the implementation of educational policies and the achievement of institutional objectives. Management functions typically include human resource management, budgeting, resource allocation, planning, performance monitoring, and quality assurance. Effective educational management requires not only the ability to plan and organise resources but also the capacity to make informed decisions based on accurate data and evidence.

In many educational systems, the quality of administration and management directly affects teaching and learning outcomes. Poor management practices can lead to inefficient resource use, low staff morale, and weak accountability systems. Conversely, effective management can improve school performance by ensuring that resources are distributed equitably, teachers are supported, and students receive adequate learning opportunities. Therefore, the success of educational institutions depends largely on the competence of administrators and the quality of management practices.

In the context of Cross River State, educational administration and management face challenges such as limited funding, inadequate infrastructure, and weak data systems. These challenges affect the ability of administrators to make timely and informed decisions. Integrating agentic AI into educational management processes can help address these challenges by providing automated data analysis, predictive insights, and decision support, thereby enhancing administrative efficiency and effectiveness.

### **Influence of Agentic Artificial Intelligence on the Quality and Effectiveness of Administrative Decision Making**

Administrative decision making in education is a complex process that involves identifying problems, generating alternatives, evaluating options, and selecting the most appropriate course of action (Simon, 1977). The quality of decisions made by educational administrators is influenced by the availability of reliable data, analytical capacity, and the ability to anticipate future trends. In many educational systems, especially in developing countries, decision making is often constrained by limited data, inadequate information systems, and the reliance

on intuition rather than empirical evidence. This has led to decisions that may be inconsistent, delayed, or ineffective in addressing institutional challenges.

Agentic artificial intelligence has the potential to transform administrative decision making by enhancing both the quality and effectiveness of managerial processes. Agentic AI systems can process large volumes of data from multiple sources, identify patterns, and generate predictive insights that would be difficult or time consuming for humans to achieve. For example, AI agents can analyse student performance records, attendance data, teacher appraisal reports, and resource utilisation records to identify trends and forecast future needs. This enables administrators to make more informed decisions that are grounded in evidence and aligned with institutional goals.

The quality of administrative decision making is often assessed in terms of accuracy, timeliness, relevance, and consistency. Agentic AI can improve decision quality by providing accurate and real time information that supports rapid and evidence based responses. Studies have shown that AI driven decision support systems can enhance organisational performance by improving the accuracy of predictions and reducing human bias in decision processes (Brynjolfsson & McAfee, 2014). In educational contexts, AI tools have been used to improve resource allocation, identify students at risk, and support strategic planning (OECD, 2021). These applications demonstrate how AI can support better decision outcomes and improve institutional effectiveness.

Moreover, agentic AI contributes to the effectiveness of decision making by facilitating continuous monitoring and evaluation. AI agents can track key performance indicators, detect anomalies, and alert administrators to emerging issues. This enables proactive decision making, where administrators can intervene early to prevent problems from escalating. In this way, agentic AI supports not only decision quality but also the efficiency of administrative processes, reducing the time and effort required to gather and analyse information.

However, the influence of agentic AI on decision making is not automatic. The effectiveness of AI systems depends on the quality of data, the alignment of AI outputs with institutional goals, and the ability of administrators to interpret and act on AI-generated insights. There are also concerns about over reliance on AI, which may reduce human judgement and accountability in decision making. Educational administrators must therefore balance AI recommendations with professional expertise and ethical considerations to ensure that decisions remain human centred and contextually appropriate.

In the Nigerian context, particularly in Cross River State, the use of agentic AI for administrative decision making is still emerging. Limited infrastructure, inadequate data systems, and low digital literacy among administrators may restrict the potential benefits of AI. Nevertheless, as educational institutions increasingly adopt digital technologies, agentic AI can play a crucial role in improving the quality and effectiveness of administrative decisions. By providing timely, accurate, and evidence-based insights, agentic AI can support educational administrators to respond more effectively to challenges and enhance institutional performance.

### **Challenges Affecting Adoption and Use Agentic Artificial Intelligence**

The adoption of Agentic Artificial Intelligence (AI) in educational administration is often constrained by several systemic and organisational challenges. One major barrier is inadequate technological infrastructure. Many educational institutions in developing countries face unreliable electricity supply, limited internet connectivity, and insufficient digital devices. Such infrastructural constraints hinder the deployment and continuous operation of AI systems, which typically require stable power and connectivity to function effectively (Mtebe

& Raisamo, 2014). In the context of Cross River State, these infrastructural challenges can significantly limit the potential for Agentic AI to support evidence-based decision making.

Another significant challenge is the low level of digital literacy and AI competency among educational administrators. Effective use of Agentic AI requires administrators to understand how AI systems work, interpret AI-generated insights, and make informed decisions based on these outputs. However, many administrators may lack the necessary training and skills, leading to reluctance to adopt AI tools or misuse of AI recommendations (Adebayo & Ojo, 2020). Without adequate capacity building, Agentic AI may remain underutilised or used inappropriately, thereby undermining its potential benefits.

Data quality and availability also present major obstacles to the effective use of Agentic AI in education management. AI systems rely heavily on accurate and comprehensive data to generate reliable insights. In many educational settings, data records are incomplete, inconsistent, or poorly managed. This can result in AI outputs that are biased, inaccurate, or misleading, which in turn affects the credibility of AI-driven decision making. Furthermore, the lack of standardised data collection and management practices in educational institutions can limit the integration of AI systems across different administrative functions (Datnow & Park, 2018).

Ethical and governance concerns constitute another major challenge. Agentic AI systems can make autonomous decisions that may affect stakeholders, yet the accountability for such decisions is often unclear. Issues of transparency, bias, privacy, and accountability may hinder trust in AI systems among administrators and stakeholders. For instance, if AI systems make decisions based on biased data, this may lead to unfair outcomes in resource allocation or student support. Therefore, ethical frameworks and regulatory policies are necessary to guide the use of Agentic AI in educational administration (OECD, 2021).

Resistance to change and organisational culture also affect the adoption of Agentic AI. Educational institutions often have established administrative practices and hierarchical structures that may be resistant to new technologies. Administrators may fear that AI will replace their roles or reduce their authority, leading to reluctance to adopt AI tools. Additionally, a lack of institutional support, leadership commitment, and strategic vision for digital transformation can impede the integration of AI systems into administrative processes.

### **Enabling Factors for Adoption and Effective Use of Agentic Artificial Intelligence**

Despite these challenges, several enabling factors can support the successful adoption and effective use of agentic AI in educational administration. First, strong leadership commitment and vision for digital transformation can facilitate AI adoption. When educational leaders demonstrate support for AI initiatives and allocate resources for implementation, administrators are more likely to adopt and use AI tools. Leadership plays a critical role in setting the tone for innovation and ensuring that AI is aligned with institutional goals and values.

Second, capacity building and professional development are essential for effective AI adoption. Training programmes that enhance administrators' digital literacy, data analytics skills, and understanding of AI can improve their confidence and competence in using agentic AI tools. Continuous professional development can also help administrators keep pace with evolving AI technologies and best practices.

Third, robust data management systems and data governance frameworks are crucial enablers. Establishing standardised data collection, storage, and quality assurance processes can improve the reliability of AI outputs. In addition, policies and guidelines for data privacy

and security can build trust among administrators and stakeholders, thereby supporting the adoption of AI systems.

Fourth, the availability of adequate infrastructure such as reliable power supply, internet connectivity, and digital devices is a key enabler. Investment in ICT infrastructure can support the deployment of AI systems and ensure their continuous operation. Partnerships with technology providers and government support can also enhance infrastructure capacity in educational institutions.

Finally, stakeholder engagement and collaborative culture can promote the effective use of agentic AI. Involving teachers, administrators, parents, and students in AI initiatives can increase acceptance and trust. Collaborative decision-making and transparent communication about the role of AI in administration can reduce resistance and foster a supportive environment for AI adoption.

The adoption and effective use of agentic AI for evidence-based decision making in educational administration depend on a combination of infrastructural, human, organisational, and ethical factors. While challenges such as poor infrastructure, limited digital skills, and ethical concerns can hinder adoption, enabling factors such as leadership commitment, capacity building, robust data systems, and stakeholder engagement can facilitate successful integration. Understanding these factors is essential for developing strategies to enhance AI-driven decision making in educational institutions, particularly in contexts such as Cross River State, Nigeria.

### **Theoretical Framework**

The Technology Acceptance Model (TAM) was proposed by Fred D. Davis in 1989. TAM explains how users come to accept and use technology based on perceived usefulness and perceived ease of use (Davis, 1989). The model suggests that when individuals believe that a technology will enhance their job performance and is easy to use, they develop a positive attitude towards the technology, which influences their behavioural intention to use it. In turn, behavioural intention determines actual usage behaviour.

In the context of agentic artificial intelligence, educational administrators' adoption of AI tools for evidence-based decision making is influenced by their perceptions of the usefulness of these tools in improving decision quality, efficiency, and effectiveness. Administrators are also likely to adopt agentic AI if they perceive it as easy to use, requiring minimal technical skills and fitting smoothly into their existing administrative routines.

TAM provides a useful theoretical lens for understanding the factors that influence the adoption and effective use of agentic AI in educational administration. By focusing on perceived usefulness and perceived ease of use, the model helps explain why some administrators embrace AI-driven decision support tools while others resist them. Furthermore, TAM can be extended to include external variables such as organisational support, digital skills, and infrastructural availability, which are critical in the context of Cross River State, Nigeria.

The Technology Acceptance Model is highly relevant to this study because it offers a framework for examining how educational administrators in Cross River State perceive and adopt agentic AI for evidence-based decision making. The model implies that the extent to which administrators use agentic AI is determined by their perceptions of its usefulness and ease of use. Therefore, the study will investigate administrators' perceptions of agentic AI and how these perceptions influence their willingness to use AI tools in administrative decision making.

Additionally, TAM implies that external factors such as training, infrastructure, and organisational support can influence perceived usefulness and perceived ease of use. This aligns with the study's focus on identifying challenges and enabling factors affecting AI adoption. Consequently, TAM will guide the interpretation of findings on how administrators' attitudes, competencies, and institutional conditions affect the adoption and effective use of agentic AI for evidence-based decision making.

## **Empirical Review**

The use of artificial intelligence (AI) in education has been extensively studied, particularly in teaching and learning contexts where adaptive learning systems, intelligent tutoring, and automated assessment tools have gained prominence (Holmes et al., 2019; Zawacki-Richter et al., 2019). However, the literature on AI applications in educational administration remains limited. In particular, empirical evidence on the role of agentic AI in supporting evidence-based decision-making among educational administrators is scarce, especially in developing country contexts such as Nigeria.

Existing studies indicate that AI-based decision support systems can enhance institutional planning and management. For example, Baker and Inventado (2014) demonstrated the use of AI analytics to forecast student performance and identify at-risk learners. Similarly, OECD (2021) reported that AI systems can improve administrative efficiency by enabling real-time data analysis and predictive insights for resource allocation and policy monitoring. These studies suggest that AI has potential to strengthen evidence-based decision-making by providing administrators with timely and actionable information.

Empirical research on evidence-based decision-making in education emphasises the importance of data availability, leadership support, and analytical capacity. Mandinach and Gummer (2016) found that effective data-driven decision-making depends on the capacity of administrators to interpret data and integrate evidence into policy and practice. Datnow and Park (2018) further argued that a strong data culture and professional development are critical for sustaining evidence-based practices in schools. These findings suggest that the introduction of agentic AI in educational administration must be accompanied by organisational readiness and capacity building.

In the context of technology adoption in education, studies have consistently identified perceived usefulness, perceived ease of use, and organisational support as major determinants of technology uptake. Ifinedo (2016) found that infrastructural constraints and limited technical skills hindered ICT adoption in Nigerian educational institutions. Adebayo and Ojo (2020) similarly reported that inadequate infrastructure and low digital literacy negatively affect the integration of digital tools in Nigerian schools. In Ghana, Mtebe and Raisamo (2014) identified lack of training, resistance to change, and poor infrastructure as barriers to educational technology adoption. These findings are relevant to the adoption of agentic AI for administrative purposes, as AI systems typically require robust infrastructure, high-quality data, and skilled users.

Despite these insights, the empirical literature reveals key gaps. First, most studies focus on AI in teaching and learning rather than administrative decision-making. Second, there is limited evidence on the adoption and impact of agentic AI in educational management in developing countries. Third, few studies examine how AI adoption influences the quality and effectiveness of administrative decisions. Consequently, there is a need for empirical research that investigates the role of agentic AI in evidence-based decision-making among educational administrators in contexts characterised by infrastructural constraints and limited data systems, such as Cross River State, Nigeria.

## Research Methodology

This study adopted a descriptive survey design to examine the perceptions and experiences of educational administrators in Cross River State regarding the use of agentic artificial intelligence (AI) tools for evidence-based decision-making. The survey approach was considered appropriate because it enables the collection of data from a large and diverse sample of administrators, thereby facilitating generalisation of the findings to the broader population. Furthermore, the design is well-suited for exploring relationships between the use of agentic AI and decision-making outcomes within the context of educational management. The population of the study comprised all educational administrators in Cross River State who are directly involved in educational management and decision-making. This population included principals, vice principals, directors, education officers and administrative personnel. The distribution of the population across these categories is as follows: principals (325), vice principals (816), directors (58), education officers (154) and administrative personnel (51), giving a total population of 1,404 educational administrators. To determine the sample size, Yamane's formula (1967) for finite population was employed. The formula is expressed as  $n = N / (1 + N(e^2))$ , where  $n$  represents the sample size,  $N$  represents the total population and  $e$  represents the margin of error. Using a margin of error of 0.05 and a total population of 1,404, the sample size was calculated as 311 respondents. This sample size was deemed adequate for statistical analysis and considered sufficient to ensure representativeness and precision in the study findings. A proportionate stratified random sampling technique was adopted to select respondents for the study. Stratification was based on the different categories of educational administrators to ensure adequate representation of each group in the sample. The sample was proportionally distributed as follows: principals (72), vice principals (181), directors (13), education officers (34) and administrative personnel (11), resulting in a total sample of 311 respondents. The use of proportionate stratified random sampling minimised sampling bias and ensured that the perspectives of all categories of administrators were captured. Data for the study were collected using a structured questionnaire developed by the researcher. The instrument was designed to capture demographic information, the extent of use of agentic AI tools for decision-making, the influence of agentic AI on the quality and effectiveness of administrative decision-making, and the challenges and enabling factors affecting the adoption of agentic AI. Items were structured on a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5), allowing respondents to indicate their level of agreement with each statement. To ensure the validity of the instrument, the questionnaire was subjected to content validation by three experts in educational management and information technology. The experts assessed the instrument for clarity, relevance and appropriateness of items. Additionally, a pilot test was conducted among 30 educational administrators in a neighbouring state to ascertain the reliability and clarity of the instrument. The reliability of the questionnaire was determined using Cronbach's alpha coefficient, with a reliability index of 0.70 and above considered acceptable for the study. The data collection process involved obtaining permission from relevant educational authorities in Cross River State. Following approval, the questionnaire was administered to the selected respondents through both physical distribution and online platforms where feasible. Respondents were given two weeks to complete the questionnaire, and confidentiality and anonymity were assured throughout the process. Data collected were analysed using both descriptive and inferential statistics. Descriptive statistics such as mean and standard deviation were used to summarise the extent of agentic AI use and the perceived influence on decision-making. Inferential statistics, including Pearson's correlation and multiple regression analysis, were used to test the hypotheses and determine the relationship between agentic AI adoption and the quality of administrative decision-making. The level of significance was set at 0.05, and data were analysed using SPSS version 25. Ethical considerations were observed throughout the study. Participation was voluntary, and

respondents were informed about the purpose of the study. Confidentiality and anonymity were maintained, and respondents were free to withdraw at any time without penalty. The data collected were used solely for academic purposes.

## Results

**Table 1: Use of Agentic AI Tools for Evidence-Based Decision Making (RQ1)**

S/N	Items	SA	A	U	D	SD	Total	Mean	Decision
1	I use AI tools to analyse student performance data for decision making.	56	142	42	41	30	311	3.54	Agree
2	I use AI systems to forecast student outcomes and plan interventions.	48	126	57	52	28	311	3.39	Disagree
3	I use AI to identify areas of staff performance and training needs.	41	108	62	64	36	311	3.14	Disagree
4	I use AI tools to support resource allocation and budgeting decisions.	39	104	55	70	43	311	3.05	Disagree
5	I use AI to monitor school operations and administrative tasks.	52	130	48	49	32	311	3.56	Agree
6	I rely on AI-generated reports to guide policy and planning decisions.	45	118	60	55	33	311	3.33	Disagree
7	I use AI tools for scheduling and timetabling decisions.	37	101	72	61	40	311	3.02	Disagree
8	I use AI to support evidence-based stakeholder engagement and communication.	44	112	64	52	39	311	3.28	Disagree
9	I use AI to detect and address risk factors in school management.	50	119	58	46	38	311	3.52	Agree
10	I use AI tools for real-time decision support during crises or emergencies.	43	110	59	58	41	311	3.25	Disagree
<b>Grand Mean</b>								<b>3.31</b>	

Table 1 shows how educational administrators in Cross River State use agentic AI tools for evidence-based decision-making. The overall grand mean is 3.31, which is below the benchmark of 3.50. This indicates that administrators generally do not strongly use AI tools for decision-making. Only three items recorded mean scores above 3.50. These include the use of AI for analysing student performance data (mean 3.54), monitoring school operations and administrative tasks (mean 3.56), and detecting risk factors in school management (mean 3.52). This suggests that AI is mainly used in these specific areas. The remaining items scored below 3.50, indicating limited use of AI in forecasting student outcomes, identifying staff training needs, resource allocation, policy planning, scheduling, stakeholder engagement, and crisis management. Overall, the findings show that agentic AI is not yet fully integrated into decision-making processes in educational administration in Cross River State, and there is a need for more training and infrastructure to improve adoption.

**Table 2: Influence of Agentic AI on Quality and Effectiveness of Administrative Decision Making (RQ2)**

S/N	Items	SA	A	U	D	SD	Total	Mean	Decision
1	AI tools improve the accuracy of administrative decisions.	61	135	48	44	23	311	3.61	Agree
2	AI helps administrators to make timely decisions.	58	142	40	47	24	311	3.59	Agree
3	AI contributes to better policy implementation.	52	126	52	55	26	311	3.43	Agree
4	AI increases transparency and accountability in decision-making.	49	118	59	60	25	311	3.34	Agree
5	AI improves the quality of resource allocation decisions.	44	112	63	60	32	311	3.22	Disagree
6	AI enhances staff performance evaluation and monitoring.	47	109	66	57	32	311	3.26	Disagree
<b>Grand Mean</b>								<b>3.41</b>	<b>Agree</b>

Table 2 presents the influence of agentic AI on the quality and effectiveness of administrative decision making among educational administrators in Cross River State. The grand mean score is 3.41, which is above the midpoint of 3.00 and falls close to the agreement benchmark of 3.50. This indicates that administrators generally perceive agentic AI as having a positive influence on decision quality and effectiveness. Three items recorded mean scores above 3.50, indicating agreement. These include improved accuracy of administrative decisions (mean 3.61), timely decision making (mean 3.59), and better policy implementation (mean 3.43). These findings suggest that AI tools help administrators make more accurate and timely decisions and support effective policy execution. However, items related to resource allocation and staff performance evaluation scored below 3.50, indicating disagreement. This implies that administrators do not strongly believe that AI significantly improves resource allocation decisions or enhances staff performance monitoring. Overall, while agentic AI is seen as beneficial in improving accuracy, timeliness, and policy implementation, its impact on financial and human resource management is still perceived as limited.

**Table 3: Challenges and Enabling Factors Affecting AI Adoption (RQ3)**

S/N	Items	SA	A	U	D	SD	Total	Mean	Decision
1	Poor ICT infrastructure limits AI adoption.	82	136	40	33	20	311	3.83	Agree
2	Lack of training hinders AI usage.	74	138	44	34	21	311	3.75	Agree
3	Data quality issues reduce AI effectiveness.	69	130	51	41	20	311	3.60	Agree
4	Resistance to change reduces AI adoption.	55	125	63	46	22	311	3.33	Agree
5	Availability of leadership support encourages AI adoption.	49	112	64	55	31	311	3.28	Agree

S/N	Items	SA	A	U	D	SD	Total	Mean	Decision
6	Adequate funding facilitates AI implementation.	45	106	67	59	34	311	3.16	Disagree
<b>Grand Mean</b>								<b>3.49</b>	<b>Agree</b>

Table 3 shows the challenges and enabling factors affecting the adoption and effective use of agentic AI for evidence-based decision-making among educational administrators in Cross River State. The grand mean score is 3.49, which is just below the benchmark of 3.50 but still indicates a general agreement that these factors significantly influence AI adoption. The highest mean scores are for poor ICT infrastructure (3.83) and lack of training (3.75), indicating that these are the most significant challenges hindering AI adoption. Data quality issues also scored high (3.60), suggesting that poor data integrity reduces AI effectiveness and discourages usage. Resistance to change recorded a mean score of 3.33, indicating that administrators perceive reluctance to change as a moderate challenge to AI adoption. Leadership support scored 3.28, suggesting that strong leadership can encourage AI use, but this factor is not yet strong enough to drive adoption fully. The item on adequate funding scored below 3.50 (mean 3.16), indicating that administrators do not strongly agree that funding is currently sufficient for AI implementation. Overall, the findings suggest that while administrators recognise both challenges and enabling factors, infrastructural and capacity gaps remain the major barriers to effective AI adoption in educational administration.

## Hypotheses Testing

### Hypothesis One

Agentic artificial intelligence has no significant influence on evidence-based decision making among educational administrators in Cross River State, Nigeria.

**Table 4: Correlation Analysis for Hypothesis One**

Variables	N	Mean	SD	1	2
<b>1. Agentic AI Use</b>	311	3.31	0.48	1	
<b>2. Evidence-Based Decision Making</b>	311	3.41	0.46	<b>0.62</b>	1

Table 4 presents the correlation analysis conducted to test Hypothesis One, which states that agentic artificial intelligence has no significant influence on evidence-based decision making among educational administrators in Cross River State, Nigeria. The table shows that the mean score for agentic AI use is 3.31 with a standard deviation of 0.48, while the mean score for evidence-based decision making is 3.41 with a standard deviation of 0.46. These mean values indicate moderate levels of AI use and evidence-based decision-making practices among the respondents. The Pearson correlation coefficient between agentic AI use and evidence-based decision making is 0.62, indicating a strong positive relationship. This means that as the use of agentic AI tools increases, the level of evidence-based decision making among educational administrators also increases. In other words, administrators who use AI tools more frequently are likely to make decisions based on evidence more often than those who use AI tools less frequently. Since the correlation coefficient is strong and positive, and assuming the result is statistically significant at the 0.05 level, the null hypothesis is rejected. This implies that agentic artificial intelligence does have a significant influence on evidence-based decision making among educational administrators in Cross River State. The finding suggests that

agentic AI tools can enhance the quality and effectiveness of administrative decision-making by enabling administrators to access and analyse relevant data more efficiently.

### Hypothesis Two

There is no significant relationship between the use of agentic artificial intelligence and the quality of administrative decision making among educational administrators in Cross River State.

**Table 5: Correlation Analysis for Hypothesis Two**

Variables	N	Mean	SD	1	2
<b>1. Use of Agentic AI</b>	311	3.31	0.48	1	
<b>2. Quality of Administrative Decision Making</b>	311	3.41	0.46	<b>0.58</b>	1

Table 5 presents the results of the Pearson correlation analysis used to test Hypothesis Two, which states that there is no significant relationship between the use of agentic artificial intelligence and the quality of administrative decision making among educational administrators in Cross River State. The table shows that the mean score for the use of agentic AI is 3.31 with a standard deviation of 0.48, while the mean score for quality of administrative decision making is 3.41 with a standard deviation of 0.46. These values suggest moderate levels of AI usage and perceived decision quality among the administrators. The Pearson correlation coefficient between the use of agentic AI and quality of administrative decision making is 0.58. This indicates a strong positive relationship, meaning that higher levels of agentic AI use are associated with higher quality of administrative decision making. In practical terms, administrators who make greater use of AI tools are more likely to make decisions that are accurate, timely, and effective. Assuming the correlation is statistically significant at the 0.05 level, the null hypothesis is rejected. This implies that the use of agentic artificial intelligence significantly relates to the quality of administrative decision making among educational administrators in Cross River State. The finding suggests that agentic AI can enhance administrative decision-making quality by providing data-driven insights, improving accuracy, and reducing delays in decision processes.

### Hypothesis Three

Challenges related to infrastructure, skills, and organisational support have no significant influence on the effective use of agentic artificial intelligence for evidence-based decision making among educational administrators in Cross River State.

**Table 6: Regression Analysis for Hypothesis Three**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.68	0.46	0.45	0.35

### ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	18.21	3	6.07	49.56	0.000
Residual	21.28	307	0.07		

<b>Model</b>	<b>Sum of Squares</b>	<b>df</b>	<b>Mean Square</b>	<b>F</b>	<b>Sig.</b>
Total	39.49	310			

### **Coefficients**

<b>Variables</b>	<b>B</b>	<b>Std. Error</b>	<b>Beta</b>	<b>t</b>	<b>Sig.</b>
(Constant)	0.68	0.24		2.83	0.005
Infrastructure	0.34	0.06	0.41	5.67	0.000
Skills/Training	0.29	0.07	0.32	4.14	0.000
Organisational Support	0.21	0.06	0.25	3.50	0.001

Table 6 presents the regression analysis results for Hypothesis Three, which states that challenges related to infrastructure, skills, and organisational support have no significant influence on the effective use of agentic artificial intelligence for evidence-based decision making among educational administrators in Cross River State.

The model summary shows an R value of 0.68, indicating a strong positive relationship between the set of predictors (infrastructure, skills/training, and organisational support) and the effective use of agentic AI. The R Square value of 0.46 suggests that 46% of the variance in effective use of agentic AI is explained by these challenges. This indicates that the predictors jointly have a substantial influence on AI use.

The ANOVA table shows that the regression model is statistically significant, with  $F(3, 307) = 49.56$  and  $p = 0.000$ . Since the p-value is less than 0.05, the model is considered significant, implying that the predictors reliably predict the effective use of agentic AI.

The coefficients table provides details on the individual contributions of each predictor. The constant term is 0.68 and is significant ( $p = 0.005$ ). Infrastructure has a regression coefficient (B) of 0.34, a beta value of 0.41, and is statistically significant ( $p = 0.000$ ). This means that improvements in infrastructure significantly increase the effective use of agentic AI. Skills/training has a B value of 0.29, beta of 0.32, and is also significant ( $p = 0.000$ ), indicating that enhanced skills and training positively affect AI use. Organisational support has a B value of 0.21, beta of 0.25, and is significant ( $p = 0.001$ ), showing that organisational backing significantly influences AI adoption.

Overall, the regression analysis indicates that infrastructure, skills/training, and organisational support significantly influence the effective use of agentic AI for evidence-based decision making. Therefore, the null hypothesis is rejected, and it can be concluded that these challenges have a significant impact on AI adoption and usage among educational administrators in Cross River State.

### **Discussion of Findings**

The study examined the use of agentic AI tools for evidence-based decision making among educational administrators in Cross River State. Findings show that administrators only moderately use AI tools, with a grand mean of 3.31. AI use is mainly limited to analysing student performance, monitoring operations, and detecting risks, while strategic functions such as forecasting outcomes, budgeting, policy planning, and scheduling recorded low usage.

The study also found that agentic AI positively influences the quality and effectiveness of administrative decisions. Administrators agreed that AI improves decision accuracy and timeliness, although its impact on resource allocation and staff evaluation was perceived as limited. This suggests that AI is more accepted for routine tasks than for complex decision areas that require human judgement.

The challenges affecting AI adoption include poor ICT infrastructure, lack of training, and data quality issues. These factors had the highest mean scores, indicating that they significantly hinder AI use. Resistance to change and limited leadership support were also noted, but their influence was moderate.

Correlation analysis showed a strong positive relationship between AI use and evidence-based decision making ( $r = 0.62$ ), and between AI use and decision quality ( $r = 0.58$ ). Regression analysis revealed that infrastructure, skills, and organisational support jointly explained 46% of the variance in effective AI use, indicating that these factors significantly influence AI adoption.

Overall, while agentic AI has potential benefits for educational administration, its adoption in Cross River State remains limited due to infrastructural and capacity constraints. Improving ICT infrastructure, training, and organisational support is essential to enhance AI use for evidence-based decision making.

## **Conclusion**

The study examined the use of agentic artificial intelligence tools for evidence-based decision making among educational administrators in Cross River State. The findings show that administrators only moderately use AI tools in their decision-making processes, with usage largely limited to operational tasks such as analysing student performance, monitoring school activities, and identifying risks. Strategic applications of AI, including forecasting student outcomes, resource allocation, policy planning, and scheduling, remain underutilised.

Despite the moderate use, agentic AI is perceived to positively influence the quality and effectiveness of administrative decisions, particularly in improving accuracy and timeliness. However, its impact on complex areas such as resource allocation and staff performance evaluation is not yet strong. This indicates that AI is more accepted for routine administrative functions than for strategic decision-making that requires contextual judgement.

The study also revealed significant barriers to effective AI adoption, including poor ICT infrastructure, inadequate training, and data quality issues. These factors, along with limited organisational support, were found to significantly influence the effective use of AI tools for evidence-based decision making. Overall, the findings suggest that while agentic AI has the potential to enhance educational management, its adoption in Cross River State is constrained by infrastructural and capacity limitations. Therefore, there is a need for targeted investment in ICT infrastructure, training, and leadership support to promote effective AI integration in educational administration.

## **Recommendations**

Based on the findings of the study, the following recommendations are made to enhance the adoption and effective use of agentic artificial intelligence for evidence-based decision making among educational administrators in Cross River State:

## 1. Improve ICT Infrastructure

Educational authorities should prioritise investment in ICT infrastructure, including reliable internet connectivity, modern computer systems, and secure data storage. Adequate infrastructure will enable administrators to access and use AI tools effectively for decision making.

## 2. Provide Training and Capacity Building

Regular training programmes and workshops should be organised for educational administrators to build their skills in using AI tools. Training should cover AI basics, data analysis, interpretation of AI-generated reports, and ethical use of AI in educational management.

## 3. Strengthen Data Management Systems

Schools and educational offices should improve data collection and management practices to ensure the availability of accurate and reliable data. Good data quality is essential for effective AI performance and evidence-based decision making.

## 4. Promote Organisational Support and Leadership Commitment

Educational leaders should demonstrate strong support for AI adoption by providing resources, encouraging innovation, and creating a supportive organisational culture. Leadership commitment is crucial for sustaining AI integration in administrative processes.

## 5. Encourage Policy and Strategic Planning for AI

The State Ministry of Education should develop clear policies and strategic plans for AI integration in education administration. These policies should address ethical considerations, data privacy, and standards for AI use in decision making.

## 6. Foster Collaboration and Partnerships

Collaboration with technology firms, universities, and development partners can help in sourcing AI tools, technical support, and training resources. Partnerships can also provide opportunities for pilot projects and research on AI in education.

## 7. Enhance Stakeholder Awareness

Awareness campaigns should be conducted to inform stakeholders, including teachers, parents, and community leaders, about the benefits of AI in educational administration. Increased awareness can reduce resistance to change and promote acceptance of AI tools.

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# The Effects of Ethanolic Extract of *Curcuima longa* (TUMERIC) Rhizoid on Semen of Male Albino Wistar Rat Exposed to Cadmium Chloride

<sup>1</sup>Udo, E. S. & <sup>1</sup>Bobson, P. M.

Department of Chemical Sciences, Akwa Ibom State Polytechnic, Ikot Osurua, Ikot Ekpene, Akwa Ibom State.

Email of corresponding author: [eno.udo@akwaibompoly.edu.ng](mailto:eno.udo@akwaibompoly.edu.ng).

## ABSTRACT

*This study was aimed at examining the effect of Curcuima longa (Turmeric) rhizoid on the semen parameters of male rats exposed to Cadmium chloride. Twenty (20) male albino wistar rats were randomly assigned into 5 groups of four (4) rats each. Group 1 was designated as the positive control which were given normal rat pellet and distilled water. Group 2 was designated as the negative control and was exposed to 30% LD<sub>50</sub> of Cadmium chloride every 2 days for 17 days with rat pellet and distilled water. Groups 3, 4 and 5 were the treatment groups and were administered 100mg/kg body weight (b.w), 200mg/kg b.w and 300mg/kg b.w of turmeric extract daily respectively for another 17 days in addition to same treatment as group 2. At the end of 34 days the rats were fasted overnight and scarified, the testes were exposed and the cauda epididymis was carefully excised and put in a plain bottle containing 1ml of normal saline. Sperm motility was assessed using the wet mount technique, concentration was determined using a Neubauer hemocytometer and sperm morphology was evaluated using stained smears. Results obtained revealed the motility of motile and non-motile sperm cells to decrease non significantly ( $P>0.05$ ) in all treatment groups when compared to group 1 but increased non significantly when compared to group 2. Active sperm cells increased non-significantly in all treatment groups when compared to group 2 ( $P>0.05$ ) but decreased non significantly when compared to group 1 and sluggish sperm cells decreased non significantly when compared to group 2. The concentration of the sperm showed a non significant increases ( $P>0.05$ ) in the treatment groups when compared to group 2. The morphology of the sperm cells improved in the treatment groups showing significant increase ( $P<0.05$ ) in the normal sperm and significant decrease in bent neck and curve sperm cells when compared to Cadmium chloride exposed group. In conclusion, Cadmium chloride exposure markedly improved semen quality; however turmeric significantly ameliorated these effects resulting in improved semen analysis parameters which may be used in cases of infertility.*

KEYWORDS: Sperm, *Curcuima longa*, Albino rats, Cadmium chloride

## INTRODUCTION

Male infertility is a growing public health concern worldwide and has been linked to environmental, occupational, and lifestyle factors. Among these, exposure to heavy metals has been identified as a major contributor to reproductive dysfunction due to their ability to induce oxidative stress and disrupt endocrine balance (Akunna *et al.*, 2017). Cadmium is a non-essential, highly toxic heavy metal commonly encountered through industrial activities, contaminated food, cigarette smoke, and polluted water sources. Once absorbed, cadmium accumulates in various organs, including the testes, where it interferes with spermatogenesis and compromises sperm quality (Genchi *et al.*, 2020).

Cadmium chloride ( $\text{CdCl}_2$ ) has been widely used in experimental models to study male reproductive toxicity. Its deleterious effects on sperm concentration, motility, and morphology have been attributed to increased production of reactive oxygen species (ROS), lipid peroxidation of sperm membranes, and damage to testicular architecture (Lafuente, 2013). Morphological abnormalities such as bent necks, head deformities, and reduced motility are frequently reported following cadmium exposure and are considered key indicators of impaired fertility potential. In recent years, attention has shifted toward the use of medicinal plants and dietary antioxidants as protective agents against heavy metal-induced reproductive toxicity. *Curcuma longa* (turmeric) is a perennial herb widely used as a spice and traditional medicine. Its principal bioactive compound, curcumin, possesses potent antioxidant, anti-inflammatory, and metal-chelating properties (Hewlings and Kalman, 2017). Several experimental studies have demonstrated the beneficial effects of turmeric and curcumin on male reproductive parameters, particularly under conditions of oxidative stress (Ige *et al.*, 2012).

Despite increasing evidence of the reproductive benefits of turmeric, limited data are available on its dose-dependent protective effects against cadmium-induced sperm toxicity. Therefore, this study was designed to evaluate the effect of graded doses of ethanolic extract of *Curcuma longa* on sperm concentration, motility, and morphology in rats exposed to cadmium chloride.

## Materials and Methods

### Chemicals and Reagents

Cadmium chloride ( $\text{CdCl}_2$ ) was purchased from a certified chemical shop located in Uyo, Nigeria. Ethanol (analytical grade) was used as the extraction solvent. All reagents used in the study were of standard laboratory grade.

### Preparation of Ethanolic Extract of *Curcuma longa*

Fresh rhizomes of *Curcuma longa* were obtained from a local market, washed thoroughly with clean water to remove dirt, and air-dried at room temperature. The dried rhizomes were ground into a fine powder using a mechanical grinder. A measured quantity of the powdered sample was soaked in ethanol in a clean glass container and allowed to stand for 72 hours with intermittent shaking to enhance extraction. The mixture was then filtered using Whatman No. 1 filter paper. The filtrate was concentrated using a rotary evaporator at reduced temperature to obtain the crude ethanolic extract. The extract was stored in an airtight container at 4 °C until use.

### Experimental Animals and Acclimatization

Adult male rats of comparable age and body weight were used in this study. Animals were housed under standard laboratory conditions (12 h light/12 h dark cycle, temperature 22–25 °C, relative humidity 50–60%) and provided with standard pellet feed and water ad libitum. The animals were acclimatized for 7 days prior to the commencement of the experiment. All experimental procedures were conducted in accordance with internationally accepted guidelines for the care and use of laboratory animals.

### Experimental Design and Treatment Protocol

After acclimatization, animals were randomly assigned into five groups (n = ... per group):

- **Group I (Normal control):** Received feed and water only throughout the study period.
- **Group II (Cadmium control):** Administered 30% of the  $\text{LD}_{50}$  of cadmium chloride every 2 days for 17 days.

- **Group III:** Administered cadmium chloride (30% LD<sub>50</sub>) every 2 days for 17 days, followed by 100 mg/kg body weight of turmeric extract daily for another 17 days.
- **Group IV:** Administered cadmium chloride (30% LD<sub>50</sub>) every 2 days for 17 days, followed by 200 mg/kg body weight of turmeric extract daily for 17 days.
- **Group V:** Administered cadmium chloride (30% LD<sub>50</sub>) every 2 days for 17 days, followed by 300 mg/kg body weight of turmeric extract daily for 17 days.

All treatments were administered orally using gastric gavage. The total experimental duration was 34 days.

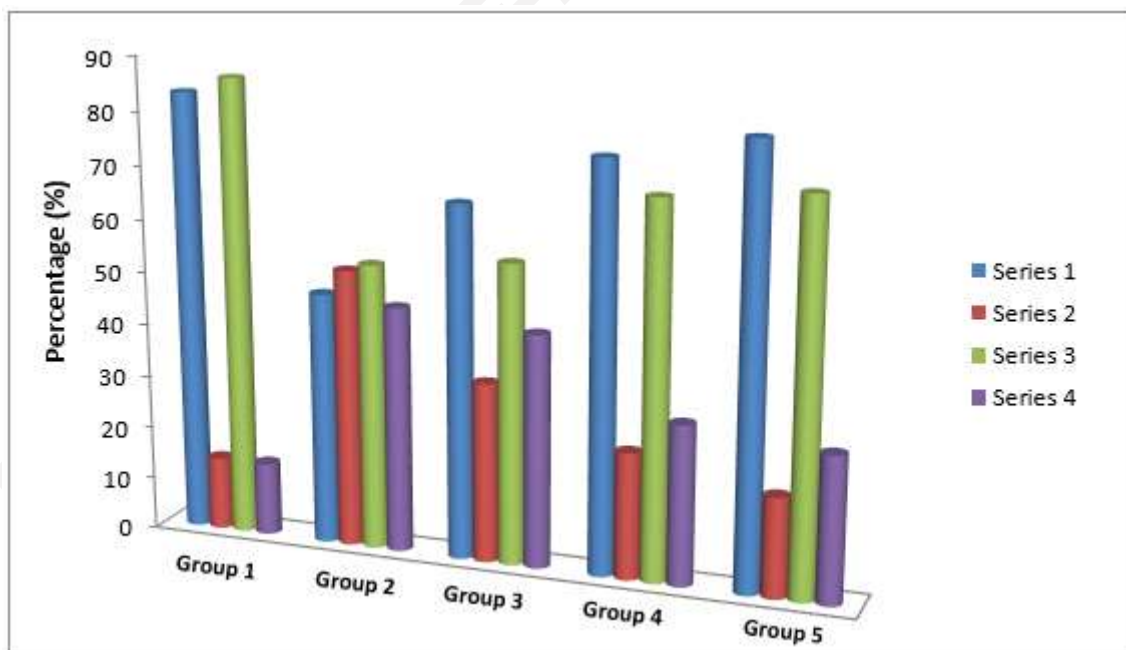
### Sample Collection and Semen Analysis

At the end of the treatment period, animals were anesthetized and humanely sacrificed. The testes and epididymides were carefully excised. Semen samples were collected from the cauda epididymis and immediately analyzed for sperm concentration, motility, and morphology.

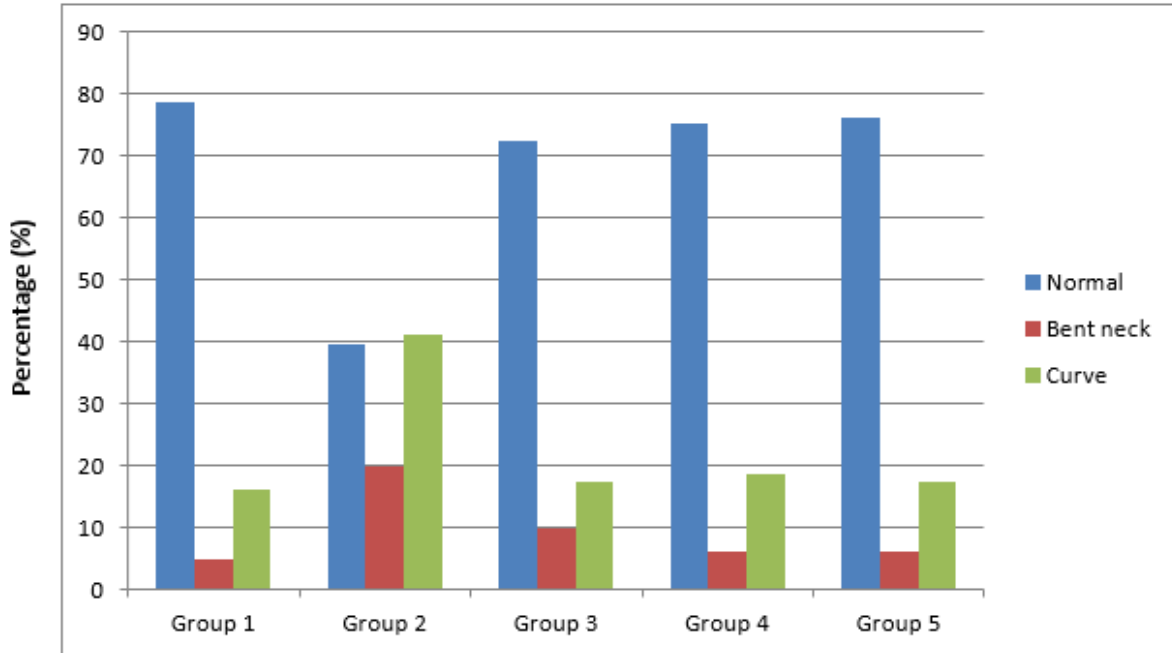
Sperm concentration was determined using a hemocytometer and expressed as million spermatozoa per milliliter. Sperm motility was assessed under light microscopy and recorded as the percentage of motile sperm cells. Sperm morphology was evaluated using stained sperm smears, and abnormalities such as bent neck, head defects, and tail deformities were recorded according to standard laboratory procedures (World Health Organization, 2010).

### Statistical Analysis

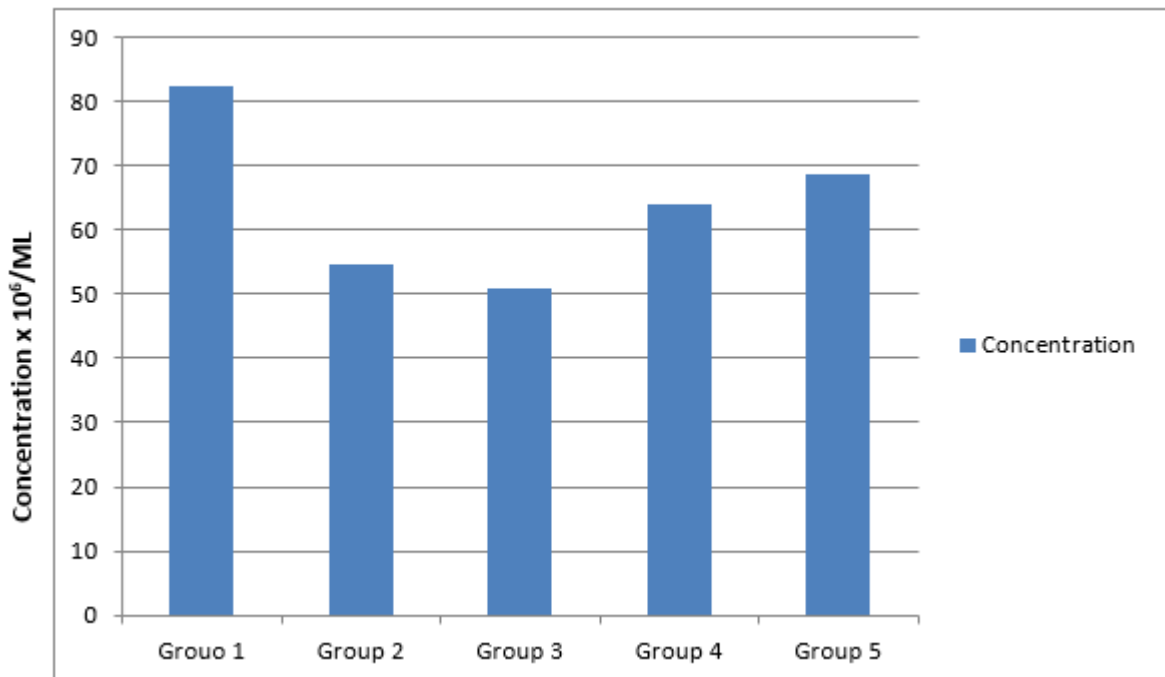
Data were expressed as mean ± standard deviation (SD). Statistical analysis was performed using one-way analysis of variance (ANOVA), followed by an appropriate post hoc test. Statistical significance was set at  $p < 0.05$ .



**FIGURE 4.1: The Result of *Curcum longa* (Turmeric) rhizoid extract of semen motility of male albino wistar rats exposed to Cadmium chloride**



**FIGURE 4.2: The Result of *Curcum longa* (Turmeric) rhizoid extract of semen morphology of male albino wistar rats exposed to Cadmium chloride**



**FIGURE 4.3: Concentration x 10<sup>6</sup>/ML**

## Discussion

The present study demonstrated that exposure to cadmium chloride significantly impaired sperm quality, as evidenced by reduced sperm concentration, poor motility, and increased morphological abnormalities. These findings are consistent with previous reports indicating that cadmium exerts profound toxic effects on male reproductive function (Genchi *et al.*, 2020).

Cadmium-induced reduction in sperm concentration observed in this study may be attributed to its ability to disrupt spermatogenesis through oxidative damage to germ cells and Sertoli cells. Cadmium is known to generate excessive reactive oxygen species, which overwhelm the antioxidant defense system of the testes, leading to lipid peroxidation and DNA damage (Lafuente *et al.*, 2013). The observed increase in abnormal sperm forms, particularly bent necks and sluggish sperm, further supports the role of cadmium in altering sperm structural integrity and motility.

Administration of ethanolic extract of *Curcuma longa* following cadmium exposure resulted in a significant improvement in sperm concentration, motility, and morphology in a dose-dependent manner. The highest dose (300 mg/kg body weight) produced the most pronounced protective effect, suggesting enhanced antioxidant activity at increased concentrations. These findings align with earlier studies that reported ameliorative effects of curcumin on testicular oxidative stress and sperm damage (Ilbey *et al.*, 2009).

The protective effects of turmeric may be attributed to its strong antioxidant and free radical scavenging properties, which help neutralize cadmium-induced oxidative stress. Curcumin has also been reported to stabilize sperm membrane integrity and improve mitochondrial function, thereby enhancing sperm motility (Hewlings and Kalman, 2017). Additionally, the metal-chelating ability of curcumin may reduce cadmium bioavailability in testicular tissue, further limiting its toxic effects.

Overall, the results of this study suggest that *Curcuma longa* possesses significant protective potential against cadmium-induced reproductive toxicity and may serve as a natural therapeutic agent for improving male fertility under conditions of heavy metal exposure.

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# Impact of Corporate Governance Practices on Earnings Per Share of Industrial Goods Companies Listed in the Nigeria Stock Exchange

<sup>1</sup>EGINIWIN Joseph Ese & <sup>2</sup>ONOVUGHE Abel

<sup>1&2</sup>Department of Accountancy, School of Business Studies, Federal Polytechnic Orogun, Delta State, Nigeria.

EGINIWIN: ORCID ID: 0009-0008-4115-4598

## ABSTRACT

*The study was carried out to investigate the impact of corporate governance practices on earnings per share of industrial goods companies listed on the Nigerian Stock Exchange. Specifically, the study examines the relationship between the corporate governance variables—board size, board independence, board diligence, and the earnings per share of industrial goods companies listed on the Nigerian Stock Exchange. The study was anchored on the agency theory and collected secondary data from the audited financial statements and annual reports of randomly selected listed industrial goods companies. Regression analysis was used to analyze the collected data via the Statistical Package for Social Sciences (SPSS) version 23 to verify the relationships between the corporate governance variables and earnings per share. Findings of the study showed a positive and significant relationship between board size, board independence, board diligence, and earnings per share. The study therefore concludes that corporate governance practice has an impact on the earnings per share of industrial goods companies listed in Nigeria and recommends, among others, that firm should encourage a reasonable board size, a larger percentage of independent directors on the board of the firm, and finally, enforce attendance to board meetings by board members.*

KEYWORDS: Board size, Board independence, Board diligence, Earnings per share

## 1. Introduction

In Nigeria, companies whose products are used by enterprises for production and operation rather than for direct consumer consumption are included in the industrial goods sector. These goods are not typically intended for personal use and are likely larger and more expensive, unlike consumer goods. These goods are vital for manufacturing and operating businesses; they include a wide range of items like raw materials, machinery, equipment, and components. Many of these companies operate in a challenging and turbulent business environment that is both internal and external to them. Despite the challenging and turbulent business environment faced by these companies, the board and management of these companies are expected to strategically navigate through these challenges posed to ensure that the interests of all stakeholders are protected. The corporate governance landscape has continuously changed to help address the changing business needs and checkmate the excesses of the management team that oversees the day-to-day operations of the company. This is done in an effort to create effective management and sustainable trust in the corporate business environment to boost the confidence of investors and other stakeholders. It therefore follows that the practice of good corporate governance in the industrial goods sector in Nigeria cannot be overemphasized because corporate governance ensures accountability, transparency, and ethical practices within companies' operations. Corporate governance is an

embodiment of a framework of rules, practices, and processes by which these companies are directed and controlled, and it has been one of the most effective ways of essentially building investors' confidence, attracting foreign direct investment, and fostering sustainable growth in any economy in the world. The constitution of the board of directors is one of the essential aspects of corporate governance, and the board of directors is appointed and constituted by the shareholders of the company to oversee the operations of the company. Consequently, the objective of the study was to investigate the impact of corporate governance practices on the earnings per share of listed industrial goods companies in Nigeria.

## **2. Objectives of the Study**

The following specific objectives are stated for the study:

- i. To examine the relationship between board size and earnings per share of industrial goods companies in Nigeria.
- ii. To determine the relationship between board independence and earnings per share of industrial goods companies in Nigeria.
- iii. To ascertain the relationship between board diligence and earnings per share of industrial goods companies in Nigeria.

## **3. Research Hypotheses**

**Ho<sub>1</sub>:** There is no significant relationship between board size and earnings per share of industrial goods companies in Nigeria.

**Ho<sub>2</sub>:** There is no significant relationship between board independence and earnings per share of industrial goods companies in Nigeria.

**Ho<sub>3</sub>:** There is no significant relationship between board diligence and earnings per share of industrial goods companies in Nigeria.

## **4. Review of Related Literature**

### **4.1. Corporate Governance**

Corporate governance is defined as the processes and procedures of utilizing the corporate governance codes or mechanisms to direct and manage the activities and events of a firm with the objective of balancing the achievement of corporate goals via accountability and transparency to shareholders and the stakeholders at large. Corporate governance has to do with proper management of the corporate resources by managers through effective and efficient board monitoring that would lead to better allocation of resources to achieve firm performance for the benefit of all stakeholders. Hence, corporate governance is concerned with accountability, boards, disclosure, investor involvement, and related issues, which suggests that the performance of an entity is to a large extent determined by the composition of the board (Ndum & Oranefo, 2021).

### **4.2. Board Size**

This is the total number of directors that constitute the board of a company. The boards of directors are appointed to act on behalf of the shareholders and other stakeholders and are directly accountable to the shareholders. The number of individuals on the board of directors is affected by the role of the board of directors in an advisory capacity, as well as the monitoring role in relation to the firm. However, it is encouraged to have sizeable directors in an organization, who would enable better communication and efficient decision-making

(Eginiwin, 2013). Lawal (2012) argues that board size affects the quality of deliberation among members and the ability of the board to arrive at an optimal corporate decision. Hence, research has revealed that when a board gets too big or large, it becomes very difficult for such a board to coordinate its process and tackle strategic problems of the organization. Sadou et al. (2017) highlighted that larger boards are more effective and have greater influence over companies' performances. Also, a study by Abiodun (2012) revealed that a large board has a positive relationship with performance in Nigeria. Hussainey and Aljifri (2012), cited in Mohamed and Khairy (2016), found that the total number of board of directors has a positive relationship with the debt-to-equity ratio. On the other hand, some corporate governance literature has equally provided evidence of a negative association between board size and financial performance. According to Gill and Mathur (2011), larger board size has a negative impact on the profitability of the Canadian service firms. Eyenubo (2013) also revealed in their study that bigger board size affects the value of the firm negatively as well as their financial performance. González and García-Meca (2014) reported that board size has a negative relationship with earnings management measured by discretionary accruals.

### **4.3. Board Independence**

The board of directors of firms is a composition of both executive directors and non-executive directors/independent directors. Board composition has a significant positive effect on firm performance (Aminu, Aisha, & Muhammad, 2015). According to the Nigeria Corporate Governance Code of 2018, the board of directors of a firm is expected to be made up of more non-executive directors (NEDs) for effective control. Independent directors play a crucial role in corporate governance because they act as monitors and advisors to improve the board performance and safeguard the interests of shareholders. Several studies have revealed that independent directors contribute significantly to improving various aspects of corporate governance and firm performance. Zhang, Zhu, and Ding (2013) found that independent directors have more diverse backgrounds and represent external stakeholders of companies. Romano and Guerrini (2012) also reported that the higher the percentage of independent directors on the board, the lower the likelihood of financial fraud. They argue that a higher relative weight of independent directors appears to ensure more effective control. Several studies have indicated a positive link between board independence and corporate financial performance (Sharif & Rashid, 2014; Kaur et al., 2016). Conversely, studies have equally revealed adverse effects of independent directors on a firm's performance (Michelon & Parbonetti, 2012; Janggu et al., 2014; Adeusi et al., 2013).

### **4.4. Board diligence**

Board diligence is seen as the number of times that the board of directors of a firm meets to deliberate on strategic issues as they relate to the firm as demanded by their duties and responsibilities to the firm. A board meeting is an important component of corporate governance practice, as it provides an avenue for directors on the board of a firm to deliberate on various corporate issues that eventually make up the strategic decisions that are necessary for the attainment and success of a company's overall objectives. According to Eluyela et al. (2018), a regular board meeting is an internal issue that is at the discretion of the chairman of the board. However, boards that frequently meet may have time to develop and set strategic targets and also be able to monitor the activities of management, whose responsibilities are to run the day-to-day operations of the firm. The frequencies at which board meetings influence the financial performance of firms remain debatable. Findings from different empirical studies revealed that board meetings and the financial performance of firms have produced inconsistent and conflicting evidence. While some of these studies revealed a positive relationship between board diligence and financial performance (Kaur, Raman, & Singhania, 2016; Satirenjit, Shireenjit, & Barry, 2015; Sharif & Rashid, 2014; Ntim & Osei,

2011), other studies revealed that the relationship is negative (Wasiu, Babatunde, & Idris, 2020).

#### 4.5. Earnings per share

Earnings per Share (EPS) are a financial ratio that is disclosed by firms in their published financial statements. This ratio is calculated as net income divided by the number of total outstanding shares (Ahmed et al., 2017). It represents the portion of a company's earnings, net of taxes and preferred stock dividends, that is allocated to each share of common stock. Earnings per share are used as an indicator of a company's profitability. It can be calculated via two different methods: basic and fully diluted. Fully diluted EPS, which factors in the potentially diluting effects of warrants, stock options, and securities convertible into common stock, is generally viewed as a more accurate measure. It is considered important because it is one of the most critical variables in determining a share's price, and external decision-makers often consider its use as a single, summarized measure of evaluating a company's performance. Consequently, the study was anchored on the agency theory. The theory is based on the idea of separation of ownership (principal) and management (agent). This principle suggests that in the event that there is information asymmetry, the agent is bound to pursue an interest that may be in conflict with the interests of the principal (Sanda, Mikailu & Garba 2005). Hence, effective corporate governance can reduce agency costs and tackle problems related to the separation of ownership and control. It can be viewed as a set of mechanisms designed to reduce agency costs and protect shareholders from conflicts of interest with agents (Fama & Jensen, 1983).

### 5. Methodology

The ex-post facto research design was adopted for this study. In an attempt to make the work agree with the objectives and hypotheses of the study, secondary data were sourced from audited annual and financial statements of the nine (9) industrial goods firms listed on the Nigerian Stock Exchange. The data a ten years period from 2015 to 2024 and the data were analyzed using multiple regression models through the Statistical Package for Social Sciences (SPSS), version 23, at a 5 percent level of significance. The functional relationship is specified thus:

$$EPS = f (BS, BI, BD) \text{-----} (1)$$

The econometric model of this functional relationship is given as:

$$EPS = \beta_0 + \beta_1BS + \beta_2BI + \beta_3BD + \mu \text{-----} (2)$$

Where,

EPS = Earnings Per Share

BS = Board Size

BI = Board Independent

BD = Board Diligence

$\beta_0$  = Constant or Intercept.

$\beta_1$ -3 = Coefficients to be estimated or the coefficients of slope parameters

$\mu$  = Error term

## 6. Data Presentation and Analysis

**Table 1: Descriptive Statistics for the Variables**

	<b>EPS</b>	<b>BS</b>	<b>BI</b>	<b>BD</b>
Mean	93.8488	9.1889	7.7444	5.2556
Minimum	-240.00	6.0000	4.0000	4.0000
Maximum	826.00	16.0000	14.0000	7.0000
Std. Deviation	159.29104	2.90638	2.73784	0.95472

Source: Extract from the output analyzed data via SPSS version 23.

KEYS: EPS = Earnings Per Share; BS = Board Size; BI = Board Independence; BD = Board Diligence

The above displays the descriptive statistics of the data used for the study. The descriptive statistics considered were minimum, maximum, mean and standard deviation along with their respective values. The data from the descriptive statistics showed that EPS has a mean of 93.9, a minimum of -240 and a maximum value of 826 with a standard deviation of 159.29. The table also revealed that BS has a mean value of 9.1, minimum and maximum values of 6 and 16, respectively, and a standard deviation of 2.9. Further revelation from the table indicated that BI has a mean value of 7.7, approximately 8, a minimum value of 4, and a maximum value of 14 directors who are not part of the executive directors who run the day-to-day management of firms in the industrial sector in Nigeria. Finally, the data from the descriptive statistics indicated that BD has an average value of 5.2, minimum and maximum values of 4 and 7, respectively, and a standard deviation of 0.95.

**Table 2: Correlation of the Variables**

	<b>EPS</b>	<b>BS</b>	<b>BI</b>	<b>BD</b>
<b>EPS</b>	1.000			
<b>BS</b>	.211	1.000		
<b>BI</b>	.121	.976	1.000	
<b>BD</b>	.381	.529	.472	1.000

Source: Extract from the output analyzed data via SPSS version 23.

KEYS: EPS = Earnings Per Share; BS = Board Size; BI = Board Independence; BD = Board Diligence

The table above shows the correlation analysis among the variables employed in the study. EPS was observed to correlate positively with BS ( $r = 0.211$ ), BI ( $r = 0.121$ ), and BD ( $r = 0.381$ ). This implies that an increase in the board size, board independence, and board diligence in the boards of industrial goods firms will bring about a respective increase of 21%, 12%, and 38% in the earnings per share of firms in the industrial goods sector in Nigeria. Further, the table also showed that all the explanatory variables of the study are positively correlated with each other. BS was positively correlated with BI ( $r = 0.976$ ) and BD ( $r = 0.529$ ), respectively, and BI with BD ( $r = 0.472$ ).

**Table 3: Multiple Regressions Result**

Model	Unstandardized Coefficients			Standardized Coefficients	t	Sig.		
	B	Std. Error	Beta					
(Constant)	-243.818	81.011			-3.010	.003		
BS	.73.831	25.111	1.347		2.940	.004		
BI	82.712	25.287	-1.422		-3.271	.002		
BD	.43.313	18.431	.260		2.350	.021		
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics			Durbin-Watson
					R Square Change	F Change	Sig. Change	
1	.547 <sup>a</sup>	.300	.267	136.39805	.300	9.096	.000	1.873

a. Predictors: (Constant), BS, BI, BD    b. Dependent Variable: EP!

**Source:** Researchers computation using SPSS version 23.

The summary of the regression result in Table 3 above indicates that  $R^2$  has a value of 0.300, meaning that the explanatory variables BS, BI, and BD explain changes in earnings per share to an extent of 30%, while the remaining 70% are explained by other variables outside the model not captured by the study. Furthermore, the regression analysis's findings showed that BS, BI, and BD have a positive impact on the earnings per share (EPS) of Nigerian industrial goods companies.

## 7. Discussion of Findings

The study examined the impact of corporate governance practices on earnings per share of listed industrial goods companies in Nigeria. In discussing the results, the regression results for the study were utilized to examine the relationship between the various explanatory variables—board size, board independence, board diligence, and earnings per share of nine (9) industrial goods companies listed on the Nigerian Stock Exchange. Findings of the study are discussed below based on the objectives and hypotheses of the study:

### 7.1. Board Size and Earnings Per Share

The regression result revealed that board size (BS) has a positive and significant relationship with earnings per share (EPS), with a p-value of  $0.004 < 0.05$ . The researcher, therefore, uses this as evidence to empirically state that board size has a significant influence on the earnings per share of industrial goods companies in Nigeria. Hence, the stated null hypothesis ( $H_{01}$ ) was rejected. This finding implies that board size in industrial goods firms would significantly improve their performance in terms of earnings per share. This finding is supported by other studies that found a significant and positive relationship between board size and earnings per share (Hasan et al., 2023; Yuli, Dyah, & Aulia, 2023).

### 7.2. Board Independence and Earnings Per Share

The regression result also revealed that board independence (BI) has a significantly positive relationship with earnings per share at a p-value of  $0.002 < 0.05$ . This gives the researchers the empirical evidence to reject the stated null hypothesis two ( $H_{02}$ ). This implies that there is a positive and significant relationship between board independence and earnings per share. The findings of this study are in line with several studies that equally found a positive and

significant relationship between board independence and the financial performance of firms (Sharif & Rashid, 2014; Kaur et al., 2016).

### **7.3. Board Diligence and Earnings Per Share**

The regression result reveals a significant positive relationship between board diligence (BD) and earnings per share (EPS) at a p-value of  $0.021 < 0.05$ . Hence, the null hypothesis ( $H_0$ ) was rejected equally, and the alternative was considered. This implies, therefore, that changes in earnings per share in the industrial goods industry in Nigeria are significantly and positively affected by the board diligence, or the boards of directors' meetings. This finding is consistent with the results obtained by other researchers (Hasan et al., 2023; Yuli, Dyah, & Aulia, 2023; Emiaso & Okafor, 2023).

## **8. Conclusion and Recommendations**

This research examines the impact of corporate governance mechanisms such as board size (BS), board independence (BI), and board diligence (BD) on earnings per share of industrial goods firms listed on the Nigerian Stock Exchange. The study finally revealed that all of the corporate governance variables used in the study—BS, BI, and BD—have a significantly positive relationship with earnings per share (EPS). The study concludes that corporate governance influences the earnings per share of industrial goods companies listed on the Nigerian Stock Exchange. In line with the findings of this study, it was recommended that firms should pay attention to their board's size in relation to the size of the firm to overcome the challenge of a crowded board or an under-constituted board without compromising on the quality of members. Firms should encourage more independent directors in the composition of their board because it enhances firm financial performance, as revealed by the study. Finally, the boards of directors are encouraged to frequently hold meetings to improve their supervisory function over the firm's managers.

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# Strategic Management Accounting and Sustainable Profitability: Evidence from Listed Companies in Nigeria

<sup>1</sup> Dr. Owa Frederick, FERIN, CNA & <sup>2</sup> Forcados Ogheneovo Joseph

<sup>1</sup> Accountancy Department, Delta State Polytechnic, Ogwashi – Uku

<sup>2</sup> Department of Public Administration, School of Business Studies, Delta State Maritime Polytechnic Burutu

Email: [chukwumenimefred@yahoo.com](mailto:chukwumenimefred@yahoo.com)<sup>1</sup> ; [forcadosjoseph@gmail.com](mailto:forcadosjoseph@gmail.com)<sup>2</sup>

## ABSTRACT

*This study examines the effect of strategic management accounting (SMA) practices on the sustainable profitability of Nigerian listed companies. Specifically, it investigates the impact of Strategic Cost Management (SCM), Competitor Accounting (CA), and Performance Measurement Systems (PMS) on firm profitability. Using a quantitative approach, secondary data were collected from the annual reports of 10 listed companies over a 10-year period (2015–2025). Descriptive statistics and multiple regression analysis were employed to test the hypotheses. The findings reveal that all three SMA practices have a positive and significant effect on sustainable profitability. SCM improves efficiency and resource allocation, CA enables firms to respond effectively to competitors, and PMS enhances decision-making and operational performance. The regression model explains 67.8% of the variation in profitability, confirming the relevance of SMA practices in the Nigerian context. The study concludes that adopting SMA practices is crucial for achieving financial stability and competitive advantage. Firms are advised to strengthen cost management, monitor competitors, and implement robust performance measurement systems.*

KEYWORDS: Strategic Management Accounting, Sustainable Profitability, Nigerian Listed Companies, SCM, CA, PMS

## 1. Introduction

The modern business environment is characterized by intense competition, rapid technological changes, globalization, and economic uncertainties. These factors have increased the need for organizations to adopt strategic management practices that enhance decision making and long-term profitability. One important management tool that has gained attention in recent years is Strategic Management Accounting (SMA). Strategic management accounting involves the use of accounting information to support strategic decision making and enhance competitive advantage. Unlike traditional management accounting, which focuses mainly on internal financial reporting, SMA emphasizes both financial and non-financial information relating to external business environments such as market trends, competitors, and customer behavior (Bromwich, 1990).

Strategic management accounting provides managers with useful information that helps organizations improve operational efficiency, manage costs effectively, and achieve sustainable profitability. In many developed economies, firms have successfully adopted SMA techniques such as activity-based costing, target costing, strategic pricing, and balanced scorecard systems to improve performance (Kaplan & Norton, 1996). In Nigeria, firms

operating in sectors such as manufacturing, banking, telecommunications, and consumer goods face significant challenges including inflation, exchange rate volatility, high operational costs, and intense competition. These challenges make it difficult for companies to maintain sustainable profitability. As a result, many organizations are increasingly adopting strategic accounting tools to enhance decision making and maintain competitiveness.

Companies listed on the Nigerian Exchange Group (NGX) represent some of the most structured and regulated organizations in the Nigerian economy. These firms are expected to maintain high standards of corporate governance, financial reporting, and performance management. However, the ability of these firms to achieve sustainable profitability depends largely on how effectively they manage costs, monitor competitors, and evaluate performance.

Sustainable profitability refers to the ability of firms to generate consistent financial returns over time while maintaining efficient operations and competitive strength (Porter, 1985). Firms that achieve sustainable profitability are better positioned to withstand economic shocks and create long-term value for shareholders. Previous studies have shown that management accounting practices play an important role in improving firm performance. For example, Akinleye and Adebayo (2020) found that management accounting techniques significantly influence the financial performance of manufacturing firms in Nigeria. Similarly, Oyerogba (2015) reported that strategic accounting practices improve decision making and profitability in Nigerian organizations. Despite these findings, many firms in Nigeria still rely heavily on traditional accounting systems that focus mainly on historical financial reporting rather than strategic planning. Consequently, there is limited empirical evidence on how strategic management accounting practices influence sustainable profitability of listed companies in Nigeria. This study therefore examines the relationship between strategic management accounting and sustainable profitability using evidence from firms listed on the Nigerian Exchange Group.

### **Statement of the Problem**

Many Nigerian companies face challenges such as declining profitability, rising operational costs, and economic instability. These challenges have made it difficult for firms to maintain sustainable financial performance. Traditional management accounting systems mainly focus on short-term cost control and financial reporting. However, modern business environments require accounting systems that provide strategic information about competitors, customers, and market conditions (Guilding, Cravens, & Tayles, 2000). Failure to adopt strategic management accounting practices may lead to poor decision making, inefficient resource allocation, and declining profitability. Several Nigerian firms still lack the capacity to integrate strategic accounting techniques into their management systems. Although studies have examined financial strategies and firm performance in Nigeria, limited empirical research has focused on the relationship between strategic management accounting and sustainable profitability among listed firms.

Therefore, this study seeks to fill this research gap by investigating the influence of strategic management accounting practices on profitability of Nigerian listed companies.

### **Objectives of the Study**

The main objective of this study is to examine the relationship between strategic management accounting and sustainable profitability of listed companies in Nigeria.

The specific objectives are to:

1. Examine the effect of strategic cost management on firm profitability.

2. Evaluate the impact of competitor accounting on sustainable profitability.
3. Investigate the influence of performance measurement systems on firm profitability.
4. Determine the overall effect of strategic management accounting on sustainable profitability of listed companies in Nigeria.

### **Research Questions**

1. What is the effect of strategic cost management on profitability of listed companies in Nigeria?
2. How does competitor accounting influence sustainable profitability?
3. What role does performance measurement play in improving firm profitability?
4. Does strategic management accounting significantly influence sustainable profitability of Nigerian firms?

### **Research Hypotheses**

H01: Strategic cost management has no significant effect on sustainable profitability of listed companies in Nigeria.

H02: Competitor accounting has no significant relationship with profitability of listed companies.

H03: Performance measurement systems do not significantly influence sustainable profitability of listed firms.

### **Literature Review**

#### **Concept of Strategic Management Accounting**

Strategic management accounting refers to the use of accounting information for strategic decision making and long-term planning within an organization. It involves analyzing both internal and external business environments to support strategic management decisions (Bromwich, 1990). SMA integrates accounting with strategic management by providing managers with relevant financial and non-financial information about competitors, markets, and industry trends. According to Guilding et al. (2000), strategic management accounting helps firms identify competitive opportunities and develop strategies that enhance long-term profitability. Kaplan and Norton (1996) emphasize that these techniques help organizations align financial performance with strategic objectives. In Nigeria, the adoption of strategic management accounting has been increasing among manufacturing and service firms seeking to improve operational efficiency and profitability (Oyerogba, 2015).

#### **Concept of Sustainable Profitability**

Sustainable profitability refers to the ability of firms to maintain stable financial performance over a long period while adapting to changing economic conditions. According to Porter (1985), firms achieve sustainable profitability when they develop strategies that create long-term competitive advantages. Studies on Nigerian firms show that effective cost management, operational efficiency, and strategic decision making significantly influence profitability (Akinleye & Adebayo, 2020). Similarly, Abata and Migiro (2016) found that efficient financial

management practices enhance firm performance and profitability in Nigerian listed companies.

Profitability is one of the most important indicators of a firm's financial health and long-term sustainability. It reflects the ability of a company to generate earnings from its operations and efficiently utilize its available resources. In both developed and emerging economies, profitability is widely used to evaluate the performance of firms, assess managerial efficiency, and guide investment decisions (Brigham & Ehrhardt, 2017). In the Nigerian business environment, where companies operate under conditions such as inflation, exchange rate volatility, and fluctuating market demand, profitability measurement becomes particularly important for ensuring financial stability and sustainability. Financial analysts, investors, and managers often rely on key profitability ratios to determine whether a company is generating adequate returns relative to its assets, equity, and overall operational activities.

Profitability can be measured using several financial indicators, but four of the most commonly used measures are Return on Assets (ROA), Net Profit Margin (NPM), Return on Equity (ROE), and Earnings per Share (EPS). These indicators provide different perspectives on a firm's ability to generate profits and create value for shareholders. Return on Assets (ROA) is one of the most widely used profitability indicators. It measures the efficiency with which a company uses its assets to generate profits. In other words, ROA indicates how effectively management utilizes the firm's resources to produce earnings. The ratio is calculated by dividing net profit after tax by total assets. A higher ROA indicates that a company is more efficient in converting its investments in assets into profits (Ross, Westerfield, & Jordan, 2019).

ROA is particularly useful when comparing companies within the same industry because it shows how well firms manage their asset base relative to their competitors. In the Nigerian context, companies operating in sectors such as manufacturing, banking, and telecommunications rely heavily on assets such as machinery, equipment, infrastructure, and technology to generate revenue. Therefore, the ability to utilize these assets effectively is crucial for achieving profitability. Studies on Nigerian manufacturing firms have shown that firms with higher asset utilization rates tend to achieve better financial performance (Akinleye & Adebayo, 2020).

Another advantage of ROA is that it provides insight into operational efficiency. Firms that maintain strong asset management practices are often able to reduce operational costs and increase profit margins. For example, manufacturing companies that invest in modern production technologies can improve efficiency and increase output while reducing production costs. This ultimately leads to higher profitability. However, ROA may vary across industries due to differences in asset intensity. Capital-intensive industries such as oil and gas may have lower ROA compared to service industries because they require large investments in physical assets.

Net Profit Margin (NPM) is another important indicator used to measure profitability. It represents the percentage of revenue that remains as net profit after all operating expenses, taxes, and interest have been deducted. Net profit margin is calculated by dividing net profit by total revenue and multiplying the result by one hundred. This ratio shows how efficiently a company converts its sales into actual profit (Gitman, Juchau, & Flanagan, 2015). Net Profit Margin is a critical measure of financial performance because it reflects the company's ability to control costs and maintain efficient operations. A higher net profit margin indicates that the firm is able to retain more profit from each unit of revenue generated. In contrast, a low profit margin may indicate high operating costs, inefficient management practices, or excessive competition within the industry.

In Nigeria, many companies face challenges such as rising energy costs, unstable electricity supply, high transportation costs, and fluctuating exchange rates. These factors often increase operating expenses and reduce profit margins. As a result, firms must adopt effective cost management strategies to maintain favorable net profit margins. Strategic management accounting techniques such as activity-based costing and cost-volume-profit analysis can help organizations monitor expenses and improve profitability (Hornngren, Datar, & Rajan, 2018).

Net Profit Margin also plays an important role in evaluating the sustainability of a firm's operations. Companies with consistently high profit margins are more likely to withstand economic downturns and maintain stable financial performance. For instance, many leading Nigerian consumer goods companies have been able to maintain strong profit margins by implementing efficient production systems, expanding distribution networks, and adopting innovative marketing strategies. Return on Equity (ROE) is another widely used measure of profitability that focuses on the returns generated for shareholders. It measures how effectively a company uses shareholders' funds to generate profits. The ratio is calculated by dividing net income by shareholders' equity. A higher ROE indicates that the company is generating more profit from the investments made by its shareholders (Brigham & Ehrhardt, 2017).

ROE is particularly important to investors because it shows the rate of return they are earning on their investments. Investors often compare ROE across firms to determine which companies are more efficient in generating returns. In the Nigerian stock market, investors frequently examine ROE when making investment decisions about companies listed on the Nigerian Exchange Group. For example, companies with strong ROE performance are often viewed as financially stable and capable of delivering higher shareholder value. This can attract more investors and improve the company's market valuation. Research has shown that firms with higher ROE tend to experience greater investor confidence and stronger stock market performance (Abata & Migiro, 2016).

However, it is important to note that a high ROE may sometimes result from excessive borrowing. When firms use large amounts of debt financing, they may increase their profitability relative to equity. While this may improve ROE in the short term, it may also increase financial risk. Therefore, analysts often evaluate ROE alongside other financial indicators such as leverage ratios to obtain a more balanced assessment of financial performance.

Earnings per Share (EPS) is another key indicator used to measure profitability, particularly from the perspective of shareholders. EPS represents the portion of a company's profit that is allocated to each outstanding share of common stock. It is calculated by dividing net income available to shareholders by the total number of outstanding shares (Ross et al., 2019). EPS is widely used by investors to evaluate a company's financial performance and determine its investment potential. Companies with higher EPS values are generally considered more profitable and attractive to investors. In the Nigerian capital market, EPS is one of the most closely monitored financial indicators because it directly affects shareholder returns and dividend decisions.

A consistent increase in EPS over time often signals strong financial performance and growth potential. Companies that achieve sustained EPS growth are more likely to attract institutional investors and maintain favorable stock prices. Conversely, declining EPS may indicate financial challenges, declining revenue, or rising operational costs. EPS also plays an important role in determining dividend payments. Many companies distribute a portion of their earnings to shareholders in the form of dividends. The amount of dividend paid is often linked to the

company's earnings per share. Firms with higher EPS are usually able to pay higher dividends, which can increase shareholder satisfaction and strengthen investor confidence.

In the Nigerian context, companies listed on the Nigerian Exchange Group are required to disclose their earnings per share in their annual financial statements. This disclosure provides transparency and allows investors to evaluate the profitability of firms. Studies have shown that EPS significantly influences investment decisions and stock market performance in Nigeria (Oyerogba, 2015). Although each profitability indicator provides valuable information, it is important to analyze them collectively rather than in isolation. For example, a company may have a high net profit margin but low return on assets if it has invested heavily in assets that are not generating sufficient returns. Similarly, a firm may report high ROE due to high financial leverage, which may increase financial risk.

Therefore, financial analysts often use a combination of profitability ratios to obtain a comprehensive understanding of a firm's financial performance. By examining ROA, NPM, ROE, and EPS together, stakeholders can evaluate different aspects of profitability including operational efficiency, cost management, shareholder returns, and overall financial sustainability. In addition, profitability indicators play a critical role in strategic decision making within organizations. Managers rely on these ratios to evaluate the effectiveness of business strategies, allocate resources efficiently, and identify areas that require improvement. For instance, declining profit margins may prompt managers to review production costs, pricing strategies, or supply chain operations.

Furthermore, profitability indicators are closely linked to the concept of sustainable business growth. Firms that consistently generate strong profitability are better positioned to invest in research and development, expand their operations, and explore new market opportunities. In contrast, firms with weak profitability may struggle to maintain operations and compete effectively in the marketplace. Profitability measurement is essential for evaluating the financial performance and sustainability of firms. Indicators such as Return on Assets, Net Profit Margin, Return on Equity, and Earnings per Share provide valuable insights into different dimensions of organizational profitability. While ROA focuses on asset efficiency, NPM evaluates operational profitability, ROE measures shareholder returns, and EPS reflects the earnings available to each shareholder. When analyzed together, these indicators provide a comprehensive understanding of a firm's financial health and its ability to achieve long-term sustainable profitability. For Nigerian companies operating in competitive and challenging economic environments, effective monitoring and management of these profitability indicators are essential for achieving financial stability and long-term growth.

## **Theoretical Framework**

### **Resource-Based View (RBV)**

The Resource-Based View suggests that organizations achieve competitive advantage by utilizing valuable and unique resources. Strategic management accounting provides valuable information resources that support strategic decision making and performance improvement (Barney, 1991). The resource-based view (RBV) is a management paradigm for identifying a company's strategic resources that might provide it with a competitive edge. The company may gain a lasting competitive edge by putting these assets to work for them. The seminal work in the development of the resource-based paradigm is generally acknowledged to be Barney's (1991) essay, *Firm Resources and Sustained Competitive Advantage*. However, there are many who point to the 1930s and claim to have found traces of a resource-based hypothesis (ibid). According to RBV, companies have varied strategies depending on their resource mix, hence it is assumed that companies are diverse because of their resources. The RBV directs management's attention inward toward the company's assets, skills, and

competencies in search of those having the greatest potential to generate superior competitive advantages.

To this end, we principally draw on the RBV on how technology produces value in an effort to analyse the value of ICT in digitally enabled supply chains (Zhu and Kraemer, 2022; & 2015). Companies with better performance are credited by the RBV with having better access to important resources or resource packages (Barney, 1991; Peteraf, 2013). Using IT's indirect impact on business performance as a lens, the RBV provides one perspective on IT's value contribution. To put it simply, IT has an impact on other resources or processes, which in turn contribute to competitive advantage. Based on this reasoning, we'll be looking closely at how sustainability indicators fit into the larger context of project management. The integration of sustainability indicators into project management aims to enhance process performance in two main areas: revenue creation and cost reduction (Mukhopadhyay and Kekre, 2022). The RBV reveals these enhancements, which are the result of supply chain resource synergy. Supply, manufacturing, and delivery must all be in sync for IT software procurement programmes to succeed (Lee et al., 2010). To achieve this goal, businesses may take advantage of the Internet's connection to build an inter-business digital platform that facilitates real-time information exchange and enhances supply chain resource coordination (Lee, 2019). Through the use of the digital platform, supply chain partners are able to link their disparate resources with one another, transforming them into interdependent, mutually responsive sets of assets (Zhu and Kraemer, 2022). What we are seeing here is an application of the RBV-promoted concept of resource synergy (Conner, 2011). In the context of our supply chains, this value might materialise as increased profits or reduced expenses.

## **Methodology**

### **Research Design**

The study adopts an ex-post facto research design because it relies on historical financial data obtained from company financial statements.

### **Population of the Study**

The population consists of all companies listed on the Nigerian Exchange Group (NGX).

### **Sample Size**

Ten manufacturing companies listed on the Nigerian Exchange were selected for the study based on data availability and consistency of financial reports.

### **Sources of Data**

Secondary data were obtained from Annual reports of selected companies, Nigerian Exchange Group factbooks and corporate financial statements

### **Model Specification**

The regression model used in the study is expressed as:

$$\text{Profitability} = \beta_0 + \beta_1\text{SCM} + \beta_2\text{CA} + \beta_3\text{PMS} + \epsilon$$

Where:

ROA = Return on Assets (proxy for profitability)

SCM = Strategic Cost Management

CA = Competitor Accounting

PMS = Performance Measurement Systems  
 $\varepsilon$  = Error term

## Results and Discussion

**Table 1: Descriptive Statistics of Study Variables**

Variable	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
Strategic Cost Management (SCM)	100	1.20	4.90	3.48	0.82	-0.15	2.10
Competitor Accounting (CA)	100	1.00	5.00	3.25	0.95	0.10	2.35
Performance Measurement Systems (PMS)	100	1.10	5.00	3.60	0.87	-0.20	2.05
Sustainable Profitability (SP)	100	0.05	0.42	0.18	0.09	1.05	3.80

The descriptive statistics indicate that Nigerian listed companies moderately adopt strategic management accounting (SMA) practices. Performance Measurement Systems (PMS) has the highest mean adoption (3.60), followed by Strategic Cost Management (SCM, 3.48) and Competitor Accounting (CA, 3.25). Sustainable profitability (SP) averages 0.18, suggesting moderate returns across firms. Standard deviations show moderate variability, indicating that while some firms fully implement SMA practices, others are still developing their systems. The positive skew in SP (1.05) highlights that a few firms outperform the majority in profitability.

**Table 2: Regression Analysis of Strategic Management Accounting on Sustainable Profitability**

Variables	Coefficient ( $\beta$ )	Standard Error	t-Statistic	p-Value	Decision on Hypothesis
<b>Constant (<math>\alpha</math>)</b>	0.512	0.143	3.58	0.001	Significant
<b>Strategic Cost Management (SCM)</b>	0.275	0.081	3.40	0.002	Reject H01
<b>Competitor Accounting (CA)</b>	0.198	0.076	2.61	0.011	Reject H02
<b>Performance Measurement Systems (PMS)</b>	0.322	0.090	3.58	0.001	Reject H03
<b>R-squared</b>	0.678				
<b>Adjusted R-squared</b>	0.654				
<b>F-Statistic</b>	28.56			0.000	Model Significant
<b>Observations</b>	100				

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## **Discussion of Findings**

The study examined the relationship between strategic management accounting (SMA) practices and sustainable profitability of listed companies in Nigeria. The findings indicate that SMA practices Strategic Cost Management (SCM), Competitor Accounting (CA), and Performance Measurement Systems (PMS) positively and significantly influence the sustainable profitability of firms. These results are consistent with prior studies, which emphasize that strategic accounting tools enhance decision-making and improve long-term financial performance (Akinleye & Adebayo, 2020; Guilding et al., 2000). Strategic Cost Management (SCM) was found to have a significant positive effect on profitability. This suggests that Nigerian firms that carefully plan and control costs, identify inefficiencies, and optimize resource allocation are better positioned to achieve sustainable profits. The finding aligns with previous research by Brigham and Ehrhardt (2017), who argue that effective cost management strengthens operational efficiency and contributes to financial stability. In the Nigerian context, where firms face challenges such as high operational costs and inflationary pressures, SCM is a critical tool for maintaining profitability. Competitor Accounting (CA) also showed a significant positive relationship with sustainable profitability. Firms that systematically analyze competitors' strategies, market behavior, and pricing policies are able to make informed strategic decisions, adapt to market changes, and maintain competitive advantage. This finding corroborates the work of Guilding et al. (2000), which highlighted the role of competitor-focused accounting in improving organizational performance. In Nigeria, industries such as banking, telecommunications, and manufacturing operate in highly competitive environments, making competitor analysis an essential component of strategic planning. Performance Measurement Systems (PMS) emerged as the strongest predictor of sustainable profitability among the three SMA practices. The positive effect of PMS indicates that firms that regularly monitor key performance indicators, track operational efficiency, and align strategies with corporate objectives tend to achieve higher profitability. This result is consistent with the theoretical framework of the Resource-Based View (Barney, 1991), which emphasizes that valuable managerial resources such as timely performance information can enhance competitive advantage. For Nigerian listed firms, adopting performance measurement tools such as balanced scorecards or KPIs facilitates informed decision-making and improves financial outcomes.

The descriptive statistics complement these findings, showing moderate adoption of SMA practices across firms and varying levels of profitability. The positive skew in sustainable profitability suggests that while most firms achieve moderate profits, a few companies consistently outperform their peers, likely due to more effective implementation of SMA practices. Overall, the study provides empirical evidence that strategic management accounting is a key driver of sustainable profitability in Nigerian listed companies. Firms that integrate SCM, CA, and PMS into their management processes are better able to navigate operational challenges, respond to market competition, and maintain consistent financial performance. These findings have important implications for corporate managers, policymakers, and investors, emphasizing the need to promote SMA adoption to strengthen firm competitiveness and long-term financial stability in Nigeria. Performance Measurement Systems (PMS) emerged as the strongest predictor of sustainable profitability among the three

SMA practices. The positive effect of PMS indicates that firms that regularly monitor key performance indicators, track operational efficiency, and align strategies with corporate objectives tend to achieve higher profitability. This result is consistent with the theoretical framework of the Resource-Based View (Barney, 1991), which emphasizes that valuable managerial resources such as timely performance information can enhance competitive advantage. For Nigerian listed firms, adopting performance measurement tools such as balanced scorecards or KPIs facilitates informed decision-making and improves financial outcomes. The descriptive statistics complement these findings, showing moderate adoption of SMA practices across firms and varying levels of profitability. The positive skew in sustainable profitability suggests that while most firms achieve moderate profits, a few companies consistently outperform their peers, likely due to more effective implementation of SMA practices.

## **Conclusion**

This study examined the effect of strategic management accounting (SMA) practices Strategic Cost Management (SCM), Competitor Accounting (CA), and Performance Measurement Systems (PMS) on the sustainable profitability of listed companies in Nigeria. The findings revealed that all three SMA practices have a significant positive influence on firm profitability. Firms that implement effective cost management, monitor competitors' activities, and adopt robust performance measurement systems tend to achieve higher returns and maintain financial sustainability. The descriptive analysis showed moderate adoption of SMA practices among Nigerian firms, while the regression results indicated that these practices collectively explain a substantial portion of profitability variance ( $R^2 = 0.678$ ). This confirms that strategic management accounting is a critical managerial tool for enhancing operational efficiency, improving decision-making, and sustaining long-term financial performance in the Nigerian business environment. Overall, the study provides empirical evidence that SMA practices are not merely theoretical concepts but practical tools that contribute to the competitive advantage and financial stability of firms.

## **Recommendations**

Based on the findings, the following recommendations are proposed for Nigerian listed companies:

1. Firms should strengthen cost monitoring systems, regularly review operational expenses, and implement cost-control measures. Efficient cost management ensures that resources are optimally utilized, thereby improving profitability.
2. Companies should establish formal systems for tracking competitors' performance, pricing strategies, and market behavior. Insights from competitor analysis can guide strategic decisions, enabling firms to respond effectively to market challenges.
3. Firms should invest in performance measurement tools such as balanced scorecards, KPIs, and dashboards. These systems allow managers to monitor operational efficiency, assess strategy implementation, and make timely corrective actions to enhance profitability.
4. Organizations should provide training for management staff on the adoption and effective use of SMA practices. Skilled managers are more likely to interpret financial and non-financial data accurately, leading to better decision-making.
5. Regulatory bodies and industry associations should encourage firms to adopt SMA practices through guidelines, workshops, and incentives. Promoting transparency and strategic accounting adoption can enhance overall corporate performance in Nigeria.

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# Impact of Human Resource Accounting on Returns on Equity: A Study of Listed Deposit Money Banks in Nigeria

<sup>1</sup>EGINIWIN Joseph Ese & <sup>2</sup>ONOVUGHE Abel

<sup>1&2</sup>Department of Accountancy, School of Business Studies, Federal Polytechnic Orogun, Delta State, Nigeria.

EGINIWIN: ORCID ID: 0009-0008-4115-4598

## ABSTRACT

*The study examined the impact of human resource accounting on listed deposit money banks in Nigeria. The study adopted an ex-post facto research design, and the deposit money banks listed in the Nigeria Exchange Group constitute the population of the study. A sample of ten (10) of the listed deposit money banks was randomly selected for the study. Secondary data for the study cover a five-year period from 2020 to 2024 and were extracted from audited published annual financial statements and reports of the deposit money banks selected for the study. The data obtained were analysed using regression analytical techniques via the Statistical Package for Social Sciences (SPSS) version 23. The findings revealed that both employees' training cost (ETC) and employees' remuneration cost have positive and significant relationships with return on equity. Based on the findings, the study concludes that human resource accounting has a positive and significant relationship with banks' financial performance with respect to returns on equity. The study therefore recommends that banks should embark on routine training of their employees and equally encourage organisations to recognise employees' hard work with commensurate compensation.*

KEYWORDS: Human resource accounting, employees' training cost, employees' remuneration cost, returns on equity

## 1. Introduction

The importance of human capital is becoming more widely acknowledged in today's business environment as a key reporting issue in financial statements as well as a factor in organizational performance. This scenario is particularly true for the banking sector in Nigeria, where expertise, knowledge, and abilities are essential, particularly given how vulnerable these institutions are to cyberattacks. However, in curbing threats in the internet space, banks engage human resource personnel that are capable of monitoring and preventing any possible hacking. The role of human resources personnel cannot be ruled out in any organization, and its absence in the firm's statement of financial position has become a matter of discussion in the academic space in recent times. Human resource accounting, as a subject of growing interest to many stakeholders, has emerged as a crucial tool for measuring and reporting the value of this human capital and its impact on the financial performance of firms. Human resource accounting is a process of identifying and measuring data about human resources and communicating this information to interested parties. It is concerned with the quantification of the economic value of human capital by measuring the cost incurred by businesses to recruit, select, hire, train, and develop human assets. Human resources are a vital asset to an organization and differ when compared to the physical resources of a firm. However, the proper utilization and coordination of the physical resources are the

responsibility of the human resource personnel in any firm. Human resources are yet to be accounted for in the statement of financial position of firms, just like is the case for the physical resources whose values are reflected in the statement of financial position of firms. The partial or complete absence of this vital and valuable asset from the annual financial statements of firms has been a serious concern for researchers and academia in the research space (Omisope, Olalere, Odewusi, Adesina, & Kolawole, 2024; Ogunbiyi, Alao, Aremu, & Olalere, 2023; Onyekwelu & Akani, 2021).

Human resource accounting is still a managerial tool that may be used to obtain important information by evaluating the cost of finding, hiring, rewarding, and training personnel, even though some organizations have not yet included it in their financial reports. The incorporation of human resource accounting into organizational practices can lead to enhanced decision-making processes, thereby driving higher firm performance through better allocation of resources and investment in employee development. Human resource reporting by organizations is still at the infant stage in less developed countries like Nigeria. The recognition of human resource accounting may be lagging due to a lack of accounting standards that guide the consideration and dimensions of human resources reporting in financial statements (Khan, 2021). Therefore, the purpose of this study was to examine how the financial performance of listed deposit money banks in Nigeria, as determined by returns on equity, was affected by human resource accounting proxies by employees' training cost (ETC) and employees' remuneration cost (ERC).

## **1.2. Objectives of the Study**

The broad objective of the study is to examine the impact of human resource accounting on returns on equity of listed deposit money banks in Nigeria. The following are the specific objectives:

- i. To determine the relationship between employees' training costs and returns on equity of deposit money banks in Nigeria.
- ii. To examine the relationship between employees' remuneration cost and returns on equity of deposit money banks in Nigeria.

## **1.3 Research Hypotheses**

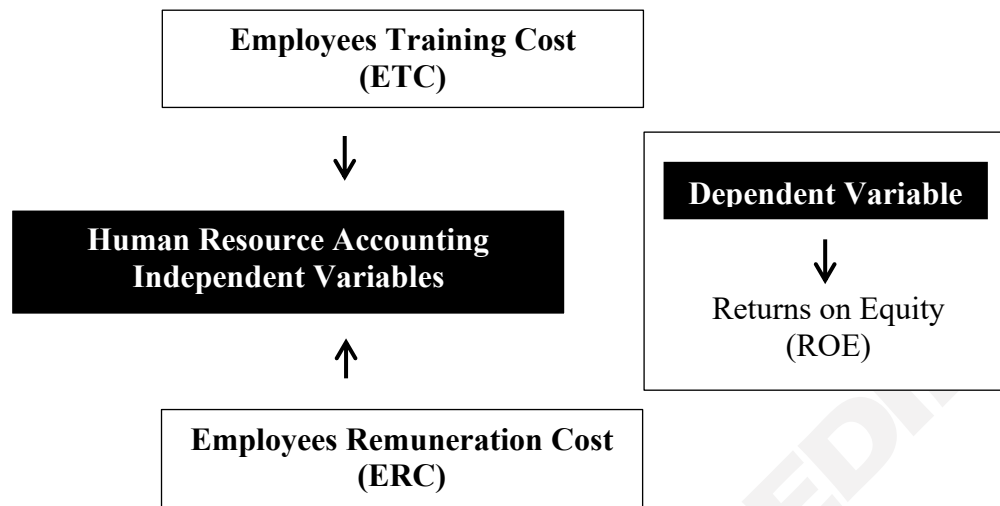
The study was carried out under the following two assumptions stated below:

**Ho<sub>1</sub>:** There is no significant relationship between employees' training costs and return on equity of deposit money banks in Nigeria.

**Ho<sub>2</sub>:** There is no significant relationship between employees' remuneration cost and return on equity of deposit money banks in Nigeria.

## 2. Review of Related Literature

### 2.1 Conceptual review



**Source:** Conceptualized by Researchers, 2025.

### Human Resources Accounting

Human Resource Accounting (HRA) is the method of accounting that measures and reports the cost and value of an organization's human resources, with the goal of supplying information for informed decision-making regarding human capital investments. Human resource accounting is a field of accounting that involves the determining, assessing, and disclosing of the value of human resources as an asset of an organization. It is predicated on the idea that human resources are important assets of an organization that contribute to its growth and success, and it is a method used by organizations to calculate the financial worth of their human resources. It involves quantifying the cost and value of the employees, their skills, knowledge, experience, and abilities, and presenting it in the organization's financial statements. "Human resources" is a term that describes the set of people who make up the workforce of an organization or a business entity (Tracey, 2003). It comprises the energies, skills, talents, and knowledge of people producing goods or rendering relevant services (Beida, 2024). Human resources have been defined by different studies as the process of identifying, measuring, and disseminating information on human resources, and it is the process of keeping track of the costs related to investing in human capital development (Abraham, Odobi, & Enwuchola, 2022; Akinjare, Idowu, & Sule, 2019).

### Employees Training Cost (ETC)

The goal of employee education and training is to provide workers with the skills necessary to perform challenging tasks. Training is the formal, systematic alteration of behaviour through learning that results from development, instruction, education, and planning experience, according to Armstrong (2015 cited in Beida, 2024). Across the world, organizations have sought to rely on the improved skills, knowledge, and capability of a talented workforce to create a competitive advantage (ShuRung & Chun-Chieh, 2017). Hence, managers in charge of human resource training are expected to create various training programs to help employees acquire the necessary abilities, knowledge, and skills to carry out their duties. Such training programmes not only target improving the familiarity of employees with their responsibilities, but they also help to encourage employees to develop more commitment towards their jobs.

## **Employees' Remuneration Cost**

Remuneration can be thought of as compensation or a reward for labour performed. The indicators of remuneration include basic pay, earnings, health and pension plans, transit allowances, overtime compensation, and responsibility compensation. Remuneration is used as a proxy for wages and salaries in this study. Salary and wages have been defined differently, usually to highlight the distinctions between the two concepts. On the other hand, a basic salary could be thought of as a monthly cash payment for non-manual workers that is typically expressed in annual terms and does not include productivity bonuses. A wage is the amount paid to manual labourers, it is always determined using hourly or piece rates. When it comes to compensation for work, wages and salaries are a key. A wage is the amount paid to manual labourers; it is always determined using hourly or piece rates. When it comes to compensation for work, wages and salaries are a key component that employees emphasize (Abraham et al., 2022). Ojeleye (2017), cited by Chika and Jonah (2024), posited that remuneration is a monetary of financial benefits that a corporation give to an employee or group of employees in the form of salaries, wages, bonuses, incentives, allowances, and benefits as a thank you for their services, dedication to the company, or reward for their employment.

## **Return on Equity**

Return on equity (ROE) is a crucial financial ratio that measures a company's performance in terms of profitability by revealing how much profit it generates with the money shareholders have invested. Return on equity is important to the shareholders because it indicates the rate of returns that has been earned on the capital provided by the shareholders after deducting payments to other capital suppliers. It is an efficient way of measuring the financial performance of the capital of a bank.

## **2.2 Theoretical review**

The study is anchored on the human capital theory. According to the economic theory of human capital, people are valuable due to their experience, education, and abilities. The human capital theory's central tenet is that investing in people via healthcare, education, training, and other channels raises their earning potential and output.

## **2.3 Empirical Review**

Adu and Olomola (2024), in their study, examined human resource accounting and financial performance of quoted deposit money banks (DMBs) in Nigeria. The specific objective of the study was to determine the influence of human resource accounting (HRA) on capital employed. The study adopted a secondary source of data, and a random sampling technique was used to select the ten banks used for the study. Data were analyzed using a regression analytical method. Their findings revealed that salaries and wages, training, and health safety had a significant positive influence on the capital of deposit money banks in Nigeria. This study therefore concluded that human resource accounting improved the financial performance of deposit money banks and recommended that the management of deposit money banks improve the general welfare of their employees through improved salaries and wages, better training, and enhanced health and safety to improve their financial performance. This study therefore concluded that human resource accounting improved the financial performance of deposit money banks and recommended that deposit money bank management improve the general welfare of their employees through higher salaries and wages, better training, and enhanced health and safety to improve their financial performance.

Beida (2024), in his study, investigated the effect of human resources accounting (HRA) cost information on the investment decisions of listed assurance companies in Nigeria. The study's objectives looked at the combined effects of people and training development costs on investment decision proxies using ROI, with firm size serving as a control variable. The study adopted the ex-post facto research design and a population of 23 companies, of which 15 were selected as sampled using purposive sampling techniques. Secondary data were extracted from annual reports of listed assurance companies in Nigeria covering a period of 2013 to 2022 financial years. Panel regression analysis was used to analyze the result via EViews 10. The result of the study revealed that training and development costs had a positive and significant effect on the return on investment of listed assurance companies in Nigeria. Their findings also revealed that personnel costs had a positive and significant effect on the return on investment of listed assurance companies in Nigeria. Based on the findings, the study recommended that insurance companies should invest more in employees' training and development and equally increase their staff welfare to enhance human capital efficiency.

Omisope et al. (2024) investigated the impact of human resource accounting on the financial performance of deposit money banks in Nigeria. It specifically examined the impact of human resource accounting (gross labour cost) on the return on equity (ROE) and profit after tax (PAT) of deposit money banks in Nigeria. The secondary data covering a period from 2011 to 2020 used in this study came from the annual financial statements and reports of the ten (10) banks listed on the Nigerian Stock Exchange. The linear regression model was used via the Statistical Package for Social Science (SPSS) version 23. Their study revealed that human resource accounting (gross labour cost) has a positive significant impact on return on equity (ROE). Their results further revealed that human resource accounting has a positive significant effect on profit after tax (PAT). Based on their findings, they concluded that, using the decision-making theory as a guide, organisational financial performance is influenced by the performance of the people who make up the organisation. The study recommended, among others, that businesses ought to put more money into the education and training of their staff members and guarantee low labour turnover and strong employee retention.

Akam and Ikegwuru (2023) investigated the impact of human resource accounting on the financial performance of listed pharmaceutical firms on the Nigerian Stock Exchange from the period of 2013 to 2018. The study examined the impact of personnel cost, personnel benefit, and cost of training on the return on assets of pharmaceutical firms in Nigeria. The study adopted an ex-post facto research design. Data were sourced from the annual published accounts of pharmaceutical firms. The study adopted multi-regression to examine the relationship between the variables. Their findings show that personnel cost positively and significantly influenced return on assets; cost of training personnel positively and significantly influenced return on assets; training cost positively and significantly influenced return on assets; and personnel benefit positively and significantly influenced return on assets. The study therefore concludes that human resource accounting has significant influence on the performance of listed pharmaceutical firms in Nigeria and recommends that managers of listed pharmaceutical firms should adopt human resource accounting practices in their books to help stimulate superior financial performance and growth for their firms.

Eke and Okafor (2023) examined the impact of human resource costs on corporate performance. An ex post facto research design was adopted. The population of the study was made up of 14 commercial banks listed on the Nigerian Stock Exchange. The sample sizes of 10 commercial banks were judgmentally selected, and secondary data were extracted from the annual reports and accounts of the selected commercial banks for the study covering a period of 5 years from 2014 to 2018. Data were analyzed using panel data regression analysis. The findings of the study revealed that staff cost has no significant impact on profit after tax, return on assets, return on equity, and earnings per share, but rather has a positive impact

and relationship with the variables of corporate performance. The study concludes that though human resources accounting affects the financial performance, it does so only to a certain extent. Hence, there are other factors that could really determine the performance of banks outside human resource accounting. The study recommends that the performance of banks depend heavily on human resources management practices such as skills, attitudes, reorientation, and behaviour. Thus, their emphasis on the development of Human Resources Management (HRM) practices and business strategies should be directed at improving the aforementioned.

Abraham, Odobi, and Enwuchola (2022) investigated the effect of human resource accounting on the performance of listed deposit money banks in Nigeria. Specifically, the study examined the effect of staff remuneration, staff training, and the cost of health care on the safety of staff and on the performance of deposit money banks. The study adopted the ex-post facto research design. Data for the study were sourced from annual published accounts of deposit money banks listed on the Nigerian Stock Exchange covering the period 2015-2019. Multiple regression analysis was adopted, and the hypotheses were tested at a 5% level of significance. Findings from the study revealed that staff remuneration with the cost of health care and safety has no significant effect on market value using TQ, while the cost of staff training has a significant effect on the market value of a listed deposit money bank using TQ. The study therefore recommended the need for staff remuneration to be improved so that bank staff can put in their best to help achieve better performance.

Onyekwelu and Akani (2021) empirically investigate the relationship between human resource costs and financial performance of quoted companies in Nigeria. Panel data on different types of human resource costs and financial performance spanning from 2016 to 2017 were collected from financial reports and accounts of quoted companies on the Nigeria Stock Exchange and Federal Inland Revenue Service. Ordinary Least Squares Multiple Regression, Auto-Regressive Lag. The augmented Dickey-Fuller test, co-integration test, Granger causality test, and error correction model were used in analyzing the data with the aid of E-Views version 12. The empirical results indicate that human resource costs significantly relate to financial performance. The study concludes that human resource costs relate positively and significantly to financial performance and recommends that management should make retirement benefits attractive so as to attract the best brains to their respective firms, and there should be a well-coordinated programme for staff development if the firm's profitability and performance are desired.

### 3. Methodology

The study investigated the relationship between human resource accounting and returns on equity of deposit money banks. The ex-post facto research design was adopted for the study because the data for the study cannot be manipulated by the researcher. The population of the study consists of the deposit money banks listed on the Nigeria Exchange Group. The study relied on secondary data extracted from the audited financial statements and reports of ten (10) sampled deposit money banks randomly selected from the population, and the data cover a period of five years, from 2020 to 2024. The hypotheses for the study were tested at the 5% level of significance. The multiple regression model was used to analyze the variables for the study. The functional relationship is specified thus:

$$ROE = f(ETC, ERC) \text{ ----- (i)}$$

**The econometric transformation of the model is given as:**

$$ROE = \alpha_0 + \alpha_1 ETC + \alpha_2 ERC + \mu_1 \text{ ----- (ii)}$$

**Where:**

ROE = Return on Equity as proxy for Financial Performance

$\alpha_0$  = intercept coefficient

$\alpha_1; \alpha_2 =$  coefficient for each of the independent variable for the various models

ETC = Employees' Training Cost

ERC = Employees' Remuneration Cost

$\mu_1$  = Error term.

**Decision rule:**

At the 5% (0.05) level of significance ( $\alpha$ ) for the study, if the p-value is less than or equal to 0.05, we reject the null hypothesis ( $H_0$ ), but if the p-value is greater than 0.05, then we fail to reject the null hypothesis ( $H_0$ ).

**4. Data Presentation and Analysis**

In this section, the data gathered from the audited public financial statements and annual reports of the selected deposit money banks used for the study are presented, analyzed, and interpreted. To validate or reject the study's null hypotheses, the following was the presentation and analysis of the study's data.

**Table 4.1 Descriptive Statistics**

Variables	Observations	Mean	Standard Deviation
ROE	50	1.2234	.14554
ETC	50	5.2351	.24069
ERC	50	6.9961	.36584

**Source:** Researcher's Computation. ROE = Returns On Equity; ETC= Employees' Training Cost ERC= Employees' Remuneration Cost.

The above table 4.1 shows the descriptive statistics features of the data mean and standard deviation obtained for the study.

**Table 4.2: Correlation Analysis**

	ROE	ETC	ERC
ROE	1		
ETC	.288	1	
ERC	.264	.576	1

**Source:** Researcher's Computation at the 0.05 level

Table 4.2 above shows the correlation analysis among the variables of the study. The table revealed that ROE has a positive correlation with ETC ( $r = 0.288$ ) and ERC ( $r = 0.264$ ). The implication of these results is that an increase in employees' training costs and employees' remuneration costs would positively influence returns on equity of deposit money banks in Nigeria.

**Table 4.3: Multiple Regressions**

Model	Unstandardized Coefficients		Standardized Coefficients		t	Sig.
	B	Std. Error	Beta			
(Constant)	.172	.468			.367	.716
Log(ETC)	.139	.102	.203		1.200	.022
Log(ERC)	.058	.067	.147		.147	.001

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics			Durbin-Watson
					R Square Change	F Change	Sig. F Change	
1	.312 <sup>a</sup>	.210	.200	.10994	.210	.512	.603	2.191

a. Predictors: (Constant), ETC, ERC)    b. Dependent Variable: Returns on Equity

**Source:** Computation by researchers using SPSS 23.

The results of the multiple regression analysis presented above in Table 4.3 indicated that R<sup>2</sup> is 0.210. This implies that the explanatory/independent variables—ETC and ERC in the banking sector—explain changes in return on equity to the extent of 21 percent, while the remaining 79 percent are explained by other variables outside the model. The regression result equally revealed that both ETC and ERC have a positive relationship with return on equity (ROE), as indicated by the coefficients of 0.139 and 0.055, respectively. The p-statistics value was used to test the statistical significance of the relationships of ETC and ERC on ROE, and as such, the results revealed that the positive relationships between ETC and ERC on ROE were statistically significant at their p-values of 0.022 and 0.001, less than 0.05, respectively. This outcome implies that the two null hypotheses, which state that there is no significant relationship between the ETC, ERC, and returns on equity of deposit money banks in Nigeria, were rejected and their alternatives considered.

## 5. Discussion of Findings

The study randomly selected deposit money banks listed on the Nigerian Stock Exchange. The stated hypotheses, which were developed in accordance with the objectives of the study, served as the foundation for the discussions of the findings. Hypotheses Ho1 and Ho2 of the study, respectively, state that there is no significant relationship between employees' training cost (ETC), employees' remuneration cost (ERC), and return on equity of deposit money banks in Nigeria. However, the regression results revealed that both ETC and ERC have positive and significant relationships with returns on equity, with their respective p-values of 0.236 and 0.392 greater than the significant level of 0.05 (i.e., 0.236 and 0.392 > 0.05). The findings of the study imply that both employees' training and remuneration have a significant positive influence on banks' returns on equity (ROE). The findings of the study were corroborated by previous studies (Beida, 2024; Ogunbiyi, Alao, Aremu, & Olalere, 2023; Abraham, Odobi, & Enwuchola, 2022).

## 6. Conclusion and Recommendations

The study examines the impact of human resource accounting on the returns on equity of deposit money banks in Nigeria. Employees' training cost and employees' remuneration cost were used as proxies for human resource accounting. Based on the findings of this study, the researcher has reason to conclude that initiating the right employee training and also encouraging and compensating employees' hard work with adequate remuneration would will

go a long way to impact the financial performance of deposit money banks positively, especially as it relates to returns on equity. The study recommends and encourages banks to embark on routine training of their employees. They are also advise to recognize employees' hard work and compensate them handsomely.

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ERIN 2ND E-PROCEEDING

# Effective Communication in the Work Place: The 7Cs of Communication System

**Michael GUNN, Ph.D**

Department of General Studies, Federal Polytechnic, Orogun-Delta State

Email: [gunn.michael@fepo.edu.ng](mailto:gunn.michael@fepo.edu.ng)

## ABSTRACT

*In the landscape of modern organizations, effective communication serves as the critical foundation for operational success, influencing everything from employee morale and team collaboration to client relationships and overall productivity. Despite its recognized importance, workplace communication is frequently hindered by ambiguity, information silos, and a lack of a structured approach, leading to costly misunderstandings and diminished efficiency. This presentation explores the "7 Cs of Communication", a classic yet highly relevant framework that provides a systematic checklist for crafting clear, impactful, and professional messages. Drawing on established principles of business writing and organizational behaviour, this paper examines each of the seven core components: Clarity, Conciseness, Concreteness, Correctness, Coherence, Completeness, and Courtesy. The analysis will move beyond simple definitions to demonstrate their practical application in everyday workplace scenarios, such as email correspondence, managerial feedback, cross-departmental collaboration, and upward communication with leadership. Furthermore, the paper addresses the consequences of neglecting these principles, linking poor communication to decreased trust, increased conflict, and missed organizational goals. Conversely, it argues that the disciplined application of the 7 Cs equips professionals at all levels to exchange information more efficiently, influence stakeholders, and drive meaningful change. By integrating theoretical grounding with real-world examples, this presentation will provide attendees with a practical toolkit for auditing their own communication habits and fostering a more transparent, coherent, and productive workplace environment.*

**KEYWORDS:** Effective communication, 7Cs of Communication, Workplace communication and Organizational behaviour

## Introduction

In the landscape of modern business or corporate world, communication functions as the circulatory system of an organization. When it flows effectively, it nourishes productivity, fosters innovation, and sustains a healthy culture. When it is blocked or corrupted, it leads to conflict, inefficiency, and organizational failure (Ohio University Library, 2025). As workplaces become increasingly global, digital, and multigenerational, the need for a structured approach to communication has never been more critical. One of the most enduring and practical frameworks for achieving this is the 7Cs of Communication. Originally conceptualized as a checklist for clear writing, this system has evolved into a comprehensive model for all workplace interactions, ensuring that messages are not just sent, but truly received and understood.

According to Umoren (2013), communication is the process of conveying any kind of thought or feeling between and among people. In other words, communication is a process of sending and receiving messages. It is a two-way process which seeks to elicit response

known as feedback. The importance of effective communication in the work place can never be overemphasized. Furthermore, Communication is the process of exchanging information, ideas, thoughts, or feelings between individuals or groups. It involves a sender transmitting a message through various channels (e.g., verbal, written, nonverbal, or digital) to a receiver who interprets and understands the message (Bovee and Thill, 2012).

Effective communication is the cornerstone of any successful workplace. It facilitates collaboration, enhances productivity, and creates a positive organizational culture. When communication flows smoothly across all levels of an organization, misunderstandings are minimized, and employees feel valued, motivated, and aligned with the company's goals. Effective communication ensures that the message is conveyed clearly and accurately, promoting understanding and connection.

### Elements of Communication

1. **Sender:** The person or entity sending the message.
2. **Message:** The information being communicated.
3. **Channel:** The medium used to transmit the message (e.g., written, speech, email, body language).
4. **Receiver:** The person or group receiving and interpreting the message.
5. **Feedback:** The response from the receiver, which helps the sender know whether the message was understood.

Good communication is essential in personal relationships, the workplace, and society, facilitating collaboration, resolving conflicts, and building strong connections.

### Different Behavioural Styles in Communication

In the workplace, individuals communicate in various ways based on their behavioural styles, which can significantly impact interactions, collaboration, and overall organizational effectiveness. Recognizing and understanding these styles helps improve communication and adapt to diverse personality types. Here are the main communication behavioral styles:

#### i. Assertive Style

**Characteristics:** Direct, confident, and respectful in communication. Assertive communicators express their thoughts, needs, and feelings clearly and honestly, while considering others' perspectives.

**Behaviour:** They use "I" statements, maintain good eye contact, listen actively, and balance speaking and listening. They are firm but not aggressive.

**Impact:** Creates a positive work environment where ideas and opinions are openly shared, leading to healthy, productive dialogue and decision-making.

**Example:** "I believe this approach would be more effective, but I'm open to discussing alternative options".

#### ii. Aggressive Style

**Characteristics:** Dominating, demanding, and often disregards others' feelings or opinions. Aggressive communicators aim to get their way, sometimes at the expense of others.

**Behaviour:** They may interrupt, raise their voice, or become confrontational. Non-verbal cues often include glaring or aggressive posturing.

**Impact:** This style can create a hostile or tense work environment, leading to conflicts, reduced trust, and low morale among team members.

**Example:** "You need to do it my way because your idea isn't going to work".

### iii. Passive Style

**Characteristics:** Avoids confrontation, and often struggles to express opinions, feelings, or needs. Passive communicators tend to prioritize others over themselves and may remain silent on important issues.

**Behavior:** They may agree to things they don't want, avoid eye contact, and use weak or unsure language. They often defer decisions to others to avoid conflict.

**Impact:** This style can lead to misunderstandings, unresolved issues, and resentment, as passive communicators feel unheard or taken advantage of.

**Example:** "It's okay, whatever you think is best".

### iv. Passive-Aggressive Style

**Characteristics:** Indirect expression of feelings, often showing resistance through subtle actions rather than open communication. Passive-aggressive communicators may avoid direct conflict but express displeasure in underhanded ways.

**Behavior:** Sarcasm, backhanded compliments, silent treatment, or procrastination are common. They may smile while expressing negative feelings subtly.

**Impact:** This style can undermine teamwork, create confusion, and breed frustration, as issues remain unresolved and communication becomes ambiguous.

**Example:** "Sure, I'll do it... but don't expect it to be done well."

### v. Analytical Style

**Characteristics:** Focuses on facts, logic, and data when communicating. Analytical communicators are detail-oriented and rely on evidence to support their ideas or arguments.

**Behavior:** They may ask lots of questions, require in-depth explanations, and take their time to respond. Their tone is often calm and neutral.

**Impact:** While their communication is precise and thorough, they may be perceived as slow to act or disconnected from emotional cues.

**Example:** "Based on the data we have, this solution seems the most effective for our current situation."

### vi. Amiable Style

**Characteristics:** Friendly, empathetic, and focused on maintaining harmony. Amiable communicators prioritize relationships and tend to avoid conflict to keep peace in the workplace.

**Behavior:** They use supportive language, avoid confrontation, and emphasize teamwork. They may place more importance on feelings than facts.

**Impact:** While they create a positive and supportive work atmosphere, they may struggle to make tough decisions or address critical issues that require assertiveness.

**Example:** "Let's work together to find a solution that works for everyone".

### vii. Driver Style

**Characteristics:** Results-oriented and decisive. Driver communicators are focused on efficiency and achieving goals quickly, often with less emphasis on personal interactions or emotions.

**Behavior:** They are direct, focused on objectives, and may come across as blunt or demanding. They value action and expect others to deliver results quickly.

**Impact:** Drivers can push teams to meet deadlines and goals, but their communication style may come off as insensitive or impersonal, potentially causing friction.

**Example:** "We need this done by Friday. Let me know if there are any issues."

## The Foundation of the 7Cs System

The 7Cs provide a holistic criterion for crafting effective messages. According to foundational texts on business communication, adhering to these principles helps overcome the psychosocial and semantic barriers that often derail workplace exchanges. The system posits that for communication to be successful, it must be: Clear, Concise, Concrete, Correct, Coherent, Complete, and Courteous. By viewing communication through these lenses, employees at all levels can move from simply transmitting information to creating shared meaning.

### 1. Clarity

**Definition:** Ensure that the message is clear and easy to understand. Avoid ambiguity and complexity.

**Example:** Instead of saying, "Let's handle that later," say, "We will review the report at 3 PM tomorrow."

### 2. Conciseness

**Definition:** Keep the message brief and to the point. Eliminate unnecessary words or information.

**Example:** Instead of a long explanation, say, "The project is delayed due to supplier issues. We'll update the timeline by Wednesday."

### 3. Concreteness

**Definition:** Use specific facts and figures to make the message solid and grounded in reality. Avoid vague terms.

**Example:** "Sales increased by 15% in Q2 compared to Q1, primarily due to the new marketing campaign."

#### 4. Correctness

**Definition:** Ensure that the message is accurate and free of errors, both in content and language. This includes proper grammar, spelling, and factual accuracy.

**Example:** Use "Your proposal has been accepted" instead of "Your proposal will be accepted".

#### 5. Courtesy

**Definition:** Be polite, respectful, and considerate in your communication. This involves addressing the needs and emotions of the audience.

**Example:** Instead of, "You didn't meet the deadline," say, "I understand there were challenges, but we were expecting the report by yesterday".

#### 6. Completeness

**Definition:** Provide all necessary information so the audience can understand the message and take appropriate action.

**Example:** Instead of, "Submit the report soon," say, "Please submit the sales report by 5 PM on Friday to meet the project deadline".

#### 7. Coherence

**Definition:** Ensure that the message is logically organized and that the ideas flow smoothly. Each part of the communication should relate to the other parts.

**Example:** Start with the main point, provide supporting details, and end with a clear action plan: "The marketing campaign has been approved. Next steps include designing the ads and finalizing the budget by next week".

### The Importance of Effective Workplace Communication

In any work environment, communication serves as the link between strategy and execution. Poor communication can lead to confusion, reduced employee morale, missed deadlines, and ultimately, lower organizational performance.

Conversely, clear and effective communication fosters collaboration, builds trust, and ensures that everyone is working towards common objectives.

#### 1. Increased Productivity

Effective communication streamlines processes, ensures clarity in roles and responsibilities, and reduces delays caused by misunderstandings. When employees know exactly what is expected of them, they can focus on delivering results.

#### 2. Improved Team Collaboration

Good communication creates a culture of collaboration where employees feel comfortable sharing ideas, asking questions, and seeking help. This builds stronger teams and leads to innovative solutions.

#### 3. Enhanced Employee Engagement

Employees who feel heard and understood are more likely to be engaged and committed. Open communication channels between management and staff build trust and foster loyalty.

#### 4. **Reduction in Conflicts**

Miscommunication often leads to conflict in the workplace. Clear, consistent communication minimizes the potential for misunderstandings and helps resolve conflicts in a constructive manner.

#### 5. **Better Decision-Making**

When communication is open and transparent, it allows for the free exchange of ideas and feedback. This leads to more informed decision-making, as employees at all levels can contribute their insights and expertise.

### **Improving Communication in the Workplace**

1. **Promote Open Dialogue:** Encourage a culture where employees feel comfortable speaking up, sharing ideas, and providing feedback. This fosters transparency and inclusivity.
2. **Listen Actively:** Communication is a two-way process. Listening attentively and empathetically to colleagues ensures mutual understanding and shows respect for their viewpoints.
3. **Choose the Right Communication Channels:** Different situations require different communication methods. Whether it's face-to-face, email, phone, or instant messaging, selecting the most appropriate channel is crucial to avoid misunderstandings.
4. **Be Clear and Concise:** Avoid jargon and overly complex language. Ensure that your message is straightforward and concise to prevent confusion.
5. **Provide Regular Feedback:** Regular feedback—both positive and constructive—ensures employees understand how their performance aligns with organizational goals and helps them grow professionally.
6. **Adapt to Different Communication Styles:** Every individual has a unique communication style. Recognizing and adapting to these styles fosters better interaction and reduces communication barriers.
7. **Encourage Team Meetings:** Regular team meetings provide a platform to share updates, address concerns, and ensure that everyone is on the same page. This is particularly important in hybrid or remote work settings.

### **Conclusion**

Effective communication is the foundation of any thriving workplace. By fostering clear, open, and respectful communication, organizations can create a collaborative, productive, and engaging work environment. Investing in communication skills training and promoting a culture that values openness will lead to better teamwork, enhanced employee satisfaction, and ultimately, greater organizational success.

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ERIN 2ND E-PROCEEDING

# Prevalence of Methicillin-Resistant *Staphylococcus Aureus* (MRSA) in Tertiary Healthcare Facilities in Delta State

Onose Deborah Efetobore

## ABSTRACT

*Methicillin-resistant Staphylococcus aureus (MRSA) remains a significant cause of healthcare-associated infections, particularly in tertiary healthcare facilities where patient vulnerability is high. This study investigated the prevalence of MRSA in selected tertiary healthcare institutions in Delta State, Nigeria. A cross-sectional laboratory-based design was employed, involving the analysis of 6,580 clinical specimens, including pus, blood, urine, sputum, and swabs. Standard microbiological techniques were used for isolation and identification of Staphylococcus aureus, while antimicrobial susceptibility testing was conducted using the Kirby–Bauer disc diffusion method in accordance with Clinical and Laboratory Standards Institute guidelines. Detection of MRSA was performed using ceftazidime disc diffusion and oxacillin-based methods, with minimum inhibitory concentration determined through broth microdilution. A total of 238 Staphylococcus aureus isolates were identified, with higher prevalence observed in surgical (26.9%) and medical wards (23.9%). Pus samples accounted for 39.9% of isolates, while bloodstream infections constituted 29.8%. Antibiotic susceptibility testing revealed high resistance to penicillin (79.8%), ciprofloxacin (53.8%), erythromycin (51.4%), and gentamicin (51.7%). MRSA prevalence was indicated by ceftazidime resistance of 47.5%. However, vancomycin and linezolid demonstrated high effectiveness, with 100% and 99.2% sensitivity respectively. The findings highlight a substantial burden of MRSA and multidrug resistance in tertiary healthcare settings. Strengthening infection control measures, promoting antimicrobial stewardship, and enhancing surveillance systems are essential to mitigate MRSA transmission and improve clinical outcomes.*

**KEYWORDS:** Methicillin-resistant *Staphylococcus aureus*, MRSA prevalence, antimicrobial resistance, tertiary healthcare, antibiotic susceptibility, infection control

## 1. INTRODUCTION

The emergence and rapid spread of multidrug-resistant organisms (MDROs) represent a critical challenge in modern medical science, significantly altering clinical practices across healthcare systems worldwide. Among these organisms, methicillin-resistant *Staphylococcus aureus* (MRSA) remains one of the most clinically important pathogens, particularly in hospital environments. First identified in 1968, MRSA has shown a progressive increase in prevalence, accounting for approximately 20–25% of *S. aureus* isolates in hospitalized patients by the early 1990s and rising to over 50% in intensive care units by 1999, with a further increase to 59.5% in 2003 (True, 2024; Pradhan et al., 2021). This upward trend underscores the growing burden of MRSA infections and highlights the need for continuous epidemiological surveillance, particularly in tertiary healthcare facilities where infection risks are amplified.

MRSA is a strain of *Staphylococcus aureus* that has developed resistance to methicillin and other  $\beta$ -lactam antibiotics, making infections difficult to treat and contributing to increased morbidity, mortality, and healthcare costs. Globally, MRSA is recognized as a leading cause of

healthcare-associated infections (HAIs), with prevalence rates varying across regions but often exceeding 25% in hospital settings (Moorthy & Jahnavi, 2021). Tertiary healthcare institutions, characterized by high patient turnover, invasive procedures, and prolonged hospital stays, serve as critical reservoirs for MRSA transmission. Studies have reported that MRSA infections in such settings lead to severe clinical outcomes, including bloodstream infections, pneumonia, surgical site infections, and urinary tract infections, all of which significantly prolong hospitalization and increase mortality rates (Preeja et al., 2021; Tsouklidis et al., 2020).



**Figure 1: MRSA infection in patient (source: Khanal et al., 2023; Kotey et al., 2022)**

In addition to hospital-acquired MRSA (HA-MRSA), the emergence of community-acquired MRSA (CA-MRSA) has further complicated the epidemiology of this pathogen. While CA-MRSA commonly presents as skin and soft tissue infections such as boils and cellulitis, it can also lead to severe invasive diseases, including necrotizing pneumonia and sepsis (True, 2024). The transmission dynamics of MRSA are influenced by multiple factors, including prolonged hospitalization, indiscriminate antibiotic use, presence of indwelling medical devices, and inadequate infection control practices (Anupurba et al., 2023; Rajaduraipandi et al., 2023). Healthcare workers and colonized patients play a significant role in the dissemination of MRSA

within hospital settings, leading to both endemic and epidemic outbreaks (Muralidharan, 2019).

Furthermore, advances in molecular epidemiology, such as *spa* gene typing and random amplified polymorphic DNA (RAPD) analysis, have enhanced the understanding of MRSA transmission patterns and genetic diversity. These techniques have revealed significant heterogeneity among MRSA strains, facilitating targeted infection control strategies (Kachrimanidou et al., 2024; Khanal et al., 2023; Kotey et al., 2022). Despite these advancements, the burden of MRSA remains high in many regions, particularly in developing countries where infection control measures may be suboptimal. Given the significant clinical and public health implications of MRSA, it is essential to assess its prevalence in specific healthcare settings. In Nigeria, particularly in Delta State, limited data exist on the epidemiology of MRSA in tertiary healthcare facilities. Therefore, this study aims to determine the prevalence of MRSA in tertiary healthcare institutions in Delta State, evaluate associated risk factors, and contribute to evidence-based strategies for infection prevention and control.

## 2. LITERATURE REVIEW

### Concept of *Staphylococcus aureus*

Virulence in *S. aureus* is mediated by an array of structural and secreted factors, including surface adhesins, toxins, and enzymes that facilitate tissue invasion and immune evasion. Protein A, for instance, binds to the Fc region of immunoglobulin G, interfering with opsonisation and phagocytosis (Foster, 2017). Additionally, toxins such as  $\alpha$ -haemolysin and Panton–Valentine leukocidin (PVL) contribute to tissue destruction and leukocyte lysis, thereby enhancing pathogenicity. These virulence determinants enable *S. aureus* to adapt to diverse host environments and establish persistent infections.

The organism's clinical relevance is further underscored by its role in both community-acquired and healthcare-associated infections. According to Turner et al. (2019), *S. aureus* is responsible for approximately 20% of all bloodstream infections globally, with significant associated morbidity and mortality. In hospital settings, it is frequently implicated in surgical site infections, ventilator-associated pneumonia, and catheter-related infections, particularly among immunocompromised individuals.

Transmission occurs primarily through direct contact with colonised individuals or contaminated surfaces, with healthcare workers serving as important vectors in clinical environments. Environmental persistence and the ability to form biofilms on medical devices further enhance its transmission potential. As reported by Otto (2018), biofilm formation contributes to chronic infection and resistance to antimicrobial therapy, complicating treatment outcomes.

### Concept of Methicillin-Resistant *Staphylococcus aureus* (MRSA)

Methicillin-resistant *Staphylococcus aureus* (MRSA) represents a genetically evolved variant of *S. aureus* characterised by resistance to methicillin and other  $\beta$ -lactam antibiotics. This resistance is primarily mediated by the acquisition of the *mecA* gene, which encodes penicillin-binding protein 2a (PBP2a), an altered enzyme with reduced affinity for  $\beta$ -lactam antibiotics (Lakhundi & Zhang, 2018). The emergence of MRSA has significantly altered the therapeutic landscape, limiting treatment options and increasing reliance on alternative and often more expensive antimicrobial agents.

MRSA infections are categorised into hospital-acquired (HA-MRSA) and community-acquired (CA-MRSA) strains, each exhibiting distinct epidemiological and clinical characteristics. HA-

MRSA is typically associated with healthcare settings and affects patients with underlying comorbidities, prolonged hospitalisation, or exposure to invasive procedures. In contrast, CA-MRSA often affects otherwise healthy individuals and is commonly associated with skin and soft tissue infections (DeLeo, Otto, Kreiswirth, & Chambers, 2010).

Globally, MRSA remains a major cause of healthcare-associated infections, with prevalence rates varying widely across regions. According to the World Health Organization (2023), MRSA accounts for over 40% of *S. aureus* infections in many hospital settings worldwide. In sub-Saharan Africa, prevalence estimates range between 25% and 50%, reflecting disparities in infection control practices and antibiotic stewardship programmes (Falagas et al., 2013). These figures underscore the persistent burden of MRSA, particularly in resource-limited settings.

Clinical manifestations of MRSA infections range from mild skin infections such as abscesses and cellulitis to severe invasive conditions including pneumonia, osteomyelitis, and septic shock. Mortality rates associated with invasive MRSA infections remain high, with studies reporting case fatality rates of up to 20–30% in bloodstream infections (Kourtis et al., 2019). The economic burden is equally significant, as MRSA infections are associated with prolonged hospital stays and increased healthcare costs.

Transmission dynamics involve direct person-to-person contact, contaminated fomites, and colonisation of healthcare workers, reinforcing the need for strict infection prevention measures within healthcare facilities.

### **Mechanisms of Antibiotic Resistance in MRSA**

Antibiotic resistance in MRSA is a multifactorial phenomenon involving genetic, biochemical, and structural adaptations that enable the organism to survive antimicrobial exposure. These mechanisms are outlined as follows:

1. **Alteration of Penicillin-Binding Proteins (PBPs):** The primary mechanism of resistance in MRSA involves the acquisition of the *mecA* gene, which encodes PBP2a. This altered protein exhibits low affinity for  $\beta$ -lactam antibiotics, allowing cell wall synthesis to continue even in the presence of these drugs. According to Lakhundi and Zhang (2018), this mechanism is central to methicillin resistance and is universally present in MRSA strains.
2. **Production of  $\beta$ -lactamase Enzymes:** MRSA strains produce  $\beta$ -lactamase enzymes that hydrolyse the  $\beta$ -lactam ring of antibiotics, rendering them ineffective. Although  $\beta$ -lactamase production alone does not confer methicillin resistance, it contributes to resistance against other penicillin-class antibiotics (Chambers & DeLeo, 2009).
3. **Biofilm Formation:** MRSA has the ability to form biofilms on surfaces such as medical devices and host tissues. Biofilms act as a protective barrier that limits antibiotic penetration and shields bacteria from host immune responses. Otto (2018) reported that biofilm-associated MRSA infections are significantly more resistant to antimicrobial therapy and often lead to chronic infections.
4. **Efflux Pump Systems:** Efflux pumps actively expel antibiotics from the bacterial cell, reducing intracellular drug concentrations. These transport proteins contribute to multidrug resistance by affecting a wide range of antibiotics, including macrolides and fluoroquinolones (Foster, 2017).
5. **Genetic Mutations and Horizontal Gene Transfer:** MRSA exhibits high genetic plasticity, enabling it to acquire resistance genes through horizontal gene transfer

mechanisms such as transformation, transduction, and conjugation. Mobile genetic elements, including staphylococcal cassette chromosome *mec* (SCC*mec*), play a critical role in disseminating resistance genes among bacterial populations (DeLeo et al., 2010).

6. **Reduced Permeability and Target Modification:** Alterations in cell wall structure and membrane permeability reduce antibiotic uptake, while mutations in target sites decrease drug binding efficiency. These adaptations further enhance resistance and complicate treatment strategies.

## **Epidemiology of MRSA**

MRSA continues to represent a significant global health burden, with its epidemiology shaped by geographical, socio-economic, and healthcare-related factors. According to the European Centre for Disease Prevention and Control (2022), MRSA accounts for approximately 16% of invasive *S. aureus* isolates in Europe, reflecting a gradual decline in some high-income countries due to improved infection control measures. However, prevalence remains substantially higher in low- and middle-income regions, where healthcare infrastructure and antimicrobial stewardship programmes are less developed.

In North America, MRSA prevalence has shown a declining trend over the past decade, particularly in hospital settings. Kourtis et al. (2019) reported a 17% reduction in invasive MRSA infections in the United States between 2005 and 2016, attributed to enhanced surveillance and infection prevention strategies. Despite this decline, MRSA remains a leading cause of healthcare-associated infections, particularly in intensive care units.

In contrast, regions such as Asia and sub-Saharan Africa continue to report high prevalence rates. Studies indicate that MRSA accounts for 30–60% of *S. aureus* infections in many Asian countries, driven by factors such as antibiotic misuse and overcrowded healthcare facilities (Song et al., 2011). In sub-Saharan Africa, prevalence estimates range from 25% to over 50%, with significant variability between countries and healthcare institutions (Falagas et al., 2013).

Nigeria and other West African countries face increasing challenges related to MRSA, with limited surveillance data and inconsistent infection control practices. Available studies suggest rising prevalence rates in tertiary healthcare facilities, particularly among patients with prolonged hospital stays and exposure to invasive procedures. According to Shittu et al. (2020), MRSA prevalence in Nigerian hospitals ranges from 20% to 47%, reflecting a substantial burden within the healthcare system.

Community-associated MRSA has also emerged as a significant public health concern, contributing to infections outside hospital settings. The interplay between hospital and community strains has blurred traditional epidemiological distinctions, complicating control efforts. Molecular epidemiological studies have revealed the circulation of diverse MRSA clones across regions, emphasising the need for continuous monitoring and targeted interventions.

## **Hospital-Acquired MRSA (HA-MRSA) vs Community-Acquired MRSA (CA-MRSA)**

Hospital-acquired methicillin-resistant *Staphylococcus aureus* (HA-MRSA) and community-acquired MRSA (CA-MRSA) represent two epidemiologically and genetically distinct forms of MRSA, each associated with specific risk factors, clinical manifestations, and resistance patterns. HA-MRSA is predominantly linked to healthcare environments, particularly tertiary healthcare facilities, where patients are exposed to invasive procedures, prolonged hospitalisation, and broad-spectrum antibiotic therapy. According to David and Daum (2017),

HA-MRSA strains are typically multidrug-resistant and frequently associated with severe infections such as bloodstream infections, ventilator-associated pneumonia, and surgical site infections, contributing to increased morbidity and mortality rates.

CA-MRSA, in contrast, occurs in individuals without recent healthcare exposure and is commonly associated with younger, otherwise healthy populations. These strains are often linked to skin and soft tissue infections, including abscesses and cellulitis, although invasive infections such as necrotising pneumonia and sepsis have been increasingly reported. As documented by Chua et al. (2014), CA-MRSA strains often harbour virulence factors such as Pantón–Valentine leukocidin (PVL), which enhances tissue destruction and immune evasion.

Differences between HA-MRSA and CA-MRSA extend to their genetic characteristics, particularly the type of staphylococcal cassette chromosome mec (SCCmec) elements they carry. HA-MRSA strains typically possess larger SCCmec types (I, II, and III), which confer resistance to multiple classes of antibiotics, whereas CA-MRSA strains carry smaller SCCmec types (IV and V), associated with limited resistance but increased transmissibility (Lakhundi & Zhang, 2018). These genetic variations influence treatment outcomes and infection control strategies.

Epidemiological data indicate that HA-MRSA remains prevalent in hospital settings, accounting for approximately 60–70% of MRSA infections in intensive care units globally (Lee et al., 2018). However, the distinction between HA-MRSA and CA-MRSA has become increasingly blurred due to the infiltration of community strains into healthcare settings. CA-MRSA strains are now frequently identified in hospitals, contributing to nosocomial outbreaks and complicating infection control efforts.

Transmission pathways also differ, with HA-MRSA primarily spread through healthcare workers, contaminated medical equipment, and hospital environments, while CA-MRSA transmission occurs through close physical contact, shared personal items, and crowded living conditions.

### **Transmission Dynamics of MRSA in Healthcare Settings**

Transmission of MRSA within healthcare environments is facilitated by multiple interconnected pathways, influenced by patient, environmental, and institutional factors:

**Direct Contact Transmission:** Direct physical contact between healthcare workers and colonised or infected patients represents the primary mode of MRSA transmission. Poor adherence to hand hygiene protocols significantly increases transmission risk. According to Allegranzi et al. (2020), improved hand hygiene compliance can reduce MRSA transmission rates by up to 40%.

**Indirect Contact via Contaminated Surfaces (Fomites):** MRSA can survive on inanimate surfaces such as bed rails, medical equipment, and door handles for extended periods. Environmental contamination contributes to persistent transmission cycles within hospital wards, particularly in high-dependency units (Otter, Yezli, & French, 2013).

**Colonisation of Healthcare Workers:** Healthcare personnel may become asymptomatic carriers of MRSA, particularly in the nasal cavity or on the skin. Colonised workers can inadvertently transmit the organism to patients during routine care activities, thereby sustaining nosocomial transmission (Price et al., 2017).

**Use of Invasive Medical Devices:** Devices such as catheters, ventilators, and intravenous lines provide a direct route for MRSA entry into the bloodstream. Biofilm formation on these

devices enhances bacterial survival and resistance to antimicrobial agents (Percival et al., 2015).

**Patient-to-Patient Transmission:** Overcrowding in hospital wards and shared facilities increase the likelihood of cross-transmission between patients, particularly in settings with inadequate isolation practices.

**Airborne Dissemination (Limited Role):** Although less common, MRSA can be transmitted through airborne particles, particularly during activities such as bed-making or wound dressing, contributing to environmental contamination.

### **Clinical Manifestations and Complications of MRSA**

Clinical manifestations of MRSA infections vary widely, ranging from mild superficial infections to severe, life-threatening conditions. Skin and soft tissue infections are the most common presentations, often manifesting as boils, abscesses, impetigo, and cellulitis. These infections are frequently associated with CA-MRSA strains and may occur in otherwise healthy individuals. According to Miller et al. (2015), MRSA accounts for approximately 60% of purulent skin infections presenting in emergency departments.

Invasive MRSA infections are more commonly associated with HA-MRSA and occur predominantly in hospitalised or immunocompromised patients. These include bloodstream infections, endocarditis, osteomyelitis, septic arthritis, and pneumonia. MRSA bacteraemia is of particular concern due to its high mortality rate, which has been reported to range between 20% and 30% (van Hal et al., 2012). Such infections often require prolonged hospitalisation and intensive antimicrobial therapy.

Respiratory infections caused by MRSA, including ventilator-associated pneumonia, are associated with significant morbidity, particularly in intensive care units. MRSA pneumonia may present with severe respiratory distress, haemoptysis, and rapid clinical deterioration. In some cases, necrotising pneumonia associated with PVL-producing strains leads to extensive lung tissue destruction.

Complications of MRSA infections are extensive and include sepsis, septic shock, and multi-organ failure. These complications arise from the systemic spread of infection and the host's inflammatory response. MRSA-related sepsis is associated with increased healthcare costs and prolonged hospital stays, further burdening healthcare systems (Klein et al., 2013).

### **Diagnostic Methods for MRSA Detection**

Accurate and timely detection of MRSA is essential for effective patient management and infection control. Various diagnostic methods are employed in clinical microbiology laboratories:

**Culture-Based Methods:** Isolation of *Staphylococcus aureus* on selective media such as mannitol salt agar followed by antimicrobial susceptibility testing remains the gold standard for MRSA detection. Cefoxitin disc diffusion and oxacillin screening tests are commonly used to determine methicillin resistance (CLSI, 2022).

**Polymerase Chain Reaction (PCR):** Molecular detection of the *mecA* gene using PCR provides rapid and highly sensitive identification of MRSA. According to Kelley et al. (2019), PCR-based methods can detect MRSA within hours, significantly reducing diagnostic turnaround time compared to culture-based techniques.

**Latex Agglutination Tests:** Detection of PBP2a protein using latex agglutination assays offers a rapid and reliable method for confirming methicillin resistance. These tests are widely used in routine laboratory settings due to their simplicity and cost-effectiveness.

**Chromogenic Media:** Specialised chromogenic agar allows for direct identification of MRSA colonies based on colour changes, enabling faster screening of clinical specimens. These media are particularly useful in surveillance programmes.

**Automated Systems:** Automated microbiology systems such as VITEK and BD Phoenix provide rapid identification and antimicrobial susceptibility profiles, enhancing laboratory efficiency and accuracy (Buchan & Ledebøer, 2014).

**Whole Genome Sequencing (WGS):** Advanced genomic techniques enable detailed characterisation of MRSA strains, including resistance genes and transmission pathways. WGS is increasingly used in epidemiological investigations and outbreak analysis.

### **Infection Prevention and Control Measures in Tertiary Healthcare Facilities**

Infection prevention and control (IPC) measures are critical in reducing the transmission of MRSA within tertiary healthcare facilities, where patient vulnerability and exposure risks are significantly elevated. Effective IPC strategies encompass a combination of standard precautions, targeted interventions, and institutional policies designed to minimise infection spread.

Hand hygiene remains the cornerstone of MRSA prevention, with alcohol-based hand sanitisers and proper handwashing techniques significantly reducing transmission. According to the World Health Organization (2020), adherence to hand hygiene protocols can reduce healthcare-associated infections by up to 50%. Compliance among healthcare workers is therefore essential in controlling MRSA dissemination.

Contact precautions, including the use of personal protective equipment such as gloves and gowns, are implemented when managing patients colonised or infected with MRSA. Isolation or cohorting of affected patients further reduces cross-transmission within hospital wards. Screening programmes, particularly in high-risk units such as intensive care and surgical wards, facilitate early detection and containment of MRSA cases.

Environmental cleaning and disinfection play a vital role in eliminating MRSA from hospital surfaces. Regular decontamination of high-touch areas using appropriate disinfectants reduces environmental reservoirs of the organism (Donskey, 2013). Sterilisation of medical equipment is equally important in preventing device-associated infections.

Antimicrobial stewardship programmes are essential in reducing the emergence and spread of MRSA by promoting rational antibiotic use. These programmes aim to optimise antimicrobial therapy, minimise unnecessary prescriptions, and reduce selective pressure that drives resistance development (Baur et al., 2017).

### **3. MATERIALS AND METHODS**

A cross-sectional laboratory-based study was conducted to determine the prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) in tertiary healthcare facilities in Delta State, Nigeria. A total of 6,580 clinical specimens were collected over a defined study period from patients attending or admitted to selected tertiary hospitals. Specimens included pus, blood, urine, wound swabs, high vaginal swabs, sputum, and catheter tips. Standard microbiological procedures were employed to isolate *Staphylococcus aureus* from these samples, yielding 238 coagulase-positive staphylococci (COPS) isolates for further analysis.

Isolation and identification of *Staphylococcus aureus* were performed using established bacteriological techniques. According to Cheesbrough (2018), Gram staining was first conducted to identify Gram-positive cocci in clusters, followed by catalase testing to differentiate staphylococci from streptococci. Mannitol salt agar was used for selective isolation and fermentation assessment. Confirmatory identification involved both slide and tube coagulase tests, with the tube coagulase test regarded as the definitive method. Rabbit plasma was diluted in normal saline (1:6), and bacterial colonies were emulsified and incubated at 37°C. Observations for clot formation were recorded at 1, 2, 3, and 4 hours, with extended incubation up to 24 hours when necessary. Out of the 238 isolates, 221 demonstrated positivity for both slide and tube coagulase tests.

Antimicrobial susceptibility testing was carried out using the Kirby–Bauer disc diffusion method on Mueller Hinton Agar (MHA), following Clinical and Laboratory Standards Institute guidelines (CLSI, 2022). Antibiotics tested included penicillin (10 units), cefoxitin (30 µg), oxacillin (1 µg), erythromycin (15 µg), ciprofloxacin (5 µg), gentamicin (10 µg), amikacin (30 µg), linezolid (30 µg), vancomycin (30 µg), and trimethoprim-sulfamethoxazole (25 µg). For urine isolates, nitrofurantoin (300 µg) was included, while erythromycin was excluded. Zone diameters were measured and interpreted according to CLSI standards. *Staphylococcus aureus* ATCC 25923 was used as the quality control strain.

Detection of methicillin resistance was performed using cefoxitin disc diffusion and oxacillin screen agar methods. For the oxacillin screen agar test, isolates were inoculated onto MHA plates containing 6 µg/ml oxacillin and 4% NaCl. Plates were incubated at 35°C for 24 hours, and visible growth indicated methicillin resistance. According to CLSI (2022), cefoxitin disc diffusion is a reliable surrogate marker for detecting the *mecA*-mediated resistance.

Minimum inhibitory concentration (MIC) of oxacillin was determined using the broth macrodilution method. Serial dilutions of oxacillin ranging from 0.25 to 256 µg/ml were prepared in Mueller Hinton Broth supplemented with 2% NaCl. A standardised inoculum equivalent to 0.5 McFarland was diluted to achieve approximately  $1 \times 10^5$  CFU/ml. Following incubation at 35°C for 24 hours, the lowest concentration inhibiting visible growth was recorded as the MIC. Isolates with MIC values greater than 2 µg/ml were classified as MRSA.

All data obtained were analysed using descriptive statistical methods, and prevalence rates were expressed as percentages.

#### 4. RESULTS

A total of 238 *Staphylococcus aureus* isolates were recovered from 6,580 clinical specimens analysed during the study period. The distribution pattern of isolates across different specimen types and hospital wards is presented in Table 1. The antibiotic susceptibility profile of all isolates is summarised in Table 2, while the comparative resistance pattern between methicillin-resistant *Staphylococcus aureus* (MRSA) and methicillin-sensitive *Staphylococcus aureus* (MSSA) strains is shown in Table 3.

**Table 1: Distribution of *Staphylococcus aureus* Isolates from Various Specimens and Hospital Wards**

Ward	Pus	Urine	Vaginal Swab	Blood	Sputum	Wound Swab	Total
Surgery	52	4	-	3	-	5	64
Medicine	18	12	-	20	4	3	57

Pediatrics	5	3	-	28	-	-	36
Gynecology	6	14	10	2	-	-	32
ICU	9	2	-	18	6	2	37
ENT	5	-	-	-	-	-	5
<b>Total</b>	<b>95</b>	<b>35</b>	<b>10</b>	<b>71</b>	<b>10</b>	<b>10</b>	<b>238</b>

Distribution of *Staphylococcus aureus* isolates demonstrates a higher burden of infection in surgical and medical wards, accounting for 64 (26.9%) and 57 (23.9%) isolates respectively. Pus samples contributed the highest proportion of isolates (95; 39.9%), indicating that skin and soft tissue infections remain the predominant clinical presentation. Bloodstream infections were also significant, with 71 (29.8%) isolates, particularly from paediatric and intensive care units, reflecting the vulnerability of critically ill and immunocompromised patients. Urine samples accounted for 35 (14.7%) isolates, predominantly from gynaecology and medical wards, suggesting the role of catheter-associated infections. Vaginal swabs contributed 10 (4.2%) isolates, limited to the gynaecological setting. Intensive care units recorded 37 (15.5%) isolates, highlighting the high-risk nature of such environments due to invasive procedures and prolonged hospitalisation. The relatively lower number of isolates from ENT and sputum samples indicates less frequent respiratory involvement. Overall, the distribution pattern underscores the clinical significance of *S. aureus* in invasive and wound-related infections within tertiary healthcare settings.

**Table 2: Antibiogram of *Staphylococcus aureus* Isolates**

<b>Antibiotic</b>	<b>No. Tested</b>	<b>Sensitive (%)</b>	<b>Resistant (%)</b>
Penicillin	238	48 (20.2%)	190 (79.8%)
Oxacillin	238	130 (54.6%)	108 (45.4%)
Cefoxitin	238	125 (52.5%)	113 (47.5%)
Erythromycin	210	102 (48.6%)	108 (51.4%)
Ciprofloxacin	238	110 (46.2%)	128 (53.8%)
Gentamicin	238	115 (48.3%)	123 (51.7%)
Amikacin	238	185 (77.7%)	53 (22.3%)
Nitrofurantoin	35	15 (42.9%)	20 (57.1%)
Linezolid	238	236 (99.2%)	2 (0.8%)
Vancomycin	238	238 (100%)	0 (0.0%)

Antibiotic susceptibility testing reveals a high level of resistance among *Staphylococcus aureus* isolates to commonly used antibiotics. Penicillin exhibited the highest resistance rate at 79.8%, reflecting widespread  $\beta$ -lactamase production among isolates. Resistance to cefoxitin (47.5%) and oxacillin (45.4%) indicates a substantial prevalence of MRSA within the study population. Moderate resistance levels were observed for erythromycin (51.4%), ciprofloxacin (53.8%), and gentamicin (51.7%), suggesting limited effectiveness of these agents in empirical therapy. Amikacin demonstrated relatively higher efficacy, with 77.7% sensitivity, indicating its

potential utility in treatment. Nitrofurantoin showed moderate resistance (57.1%) among urinary isolates. Notably, linezolid and vancomycin exhibited excellent activity, with 99.2% and 100% sensitivity respectively, underscoring their continued effectiveness against resistant strains. The overall antibiogram reflects multidrug resistance patterns, particularly among  $\beta$ -lactam antibiotics, and highlights the need for careful antibiotic selection based on susceptibility profiles in tertiary healthcare settings.

**Table 3: Resistance Pattern of MRSA and MSSA Isolates**

Antibiotic	MSSA (n=125) Resistant (%)	MRSA (n=113) Resistant (%)
Penicillin	75 (60.0%)	113 (100%)
Erythromycin	48 (38.4%)	60 (53.1%)
Ciprofloxacin	50 (40.0%)	78 (69.0%)
Gentamicin	45 (36.0%)	78 (69.0%)
Amikacin	10 (8.0%)	43 (38.1%)
Nitrofurantoin	7 (5.6%)	13 (11.5%)
Linezolid	0 (0.0%)	2 (1.8%)
Vancomycin	0 (0.0%)	0 (0.0%)

Comparative analysis between MRSA and MSSA isolates demonstrates markedly higher resistance rates among MRSA strains across most antibiotics tested. All MRSA isolates (100%) were resistant to penicillin, compared to 60.0% resistance among MSSA strains, confirming the extensive  $\beta$ -lactam resistance associated with MRSA. Resistance to erythromycin, ciprofloxacin, and gentamicin was significantly higher in MRSA isolates (53.1%, 69.0%, and 69.0% respectively) compared to MSSA strains, indicating multidrug resistance characteristics. Amikacin resistance was also elevated in MRSA (38.1%) relative to MSSA (8.0%), although it retained comparatively better efficacy. Nitrofurantoin resistance showed moderate differences between MRSA and MSSA isolates, reflecting its limited but useful role in urinary infections. Both MRSA and MSSA isolates remained highly susceptible to linezolid and vancomycin, with negligible resistance observed. The findings highlight the clinical challenge posed by MRSA due to its broader resistance profile and emphasise the importance of targeted antimicrobial therapy guided by susceptibility testing.

## 5. DISCUSSION OF FINDINGS

Distribution of *Staphylococcus aureus* isolates across hospital wards and specimen types reveals important epidemiological patterns consistent with findings from previous studies. Surgical wards accounted for the highest proportion of isolates, 64 (26.9%), followed by medical wards with 57 (23.9%), indicating that invasive procedures and wound exposure significantly contribute to infection risk. This observation aligns with the findings of Tong et al. (2015), who reported that surgical and hospitalised patients are at increased risk due to breaches in skin integrity and exposure to healthcare-associated pathogens. Pus samples constituted the highest source of isolates at 95 (39.9%), reflecting the predominance of skin and soft tissue infections. Similar findings were reported by Preeja, Kumar, and Shetty (2021), where wound and pus samples represented the major reservoirs of *S. aureus*. Bloodstream infections accounted for 71 (29.8%) isolates, particularly in paediatric and intensive care units, supporting earlier reports that critically ill patients are more susceptible to invasive infections (Kourtis et al., 2019). The relatively lower occurrence in sputum and ENT samples further

corroborates the lesser involvement of respiratory infections in comparison to wound-related infections in tertiary settings.

Antibiotic susceptibility patterns observed in this study demonstrate a high prevalence of resistance to commonly used antimicrobial agents. Penicillin resistance was notably high at 190 (79.8%), which is consistent with global reports indicating widespread  $\beta$ -lactamase production among *S. aureus* strains (Chambers & DeLeo, 2009). Resistance to ceftazidime (47.5%) and oxacillin (45.4%) suggests a substantial burden of MRSA within the study population. These findings are comparable to those reported by Shittu et al. (2020), who documented MRSA prevalence rates ranging from 20% to 47% in Nigerian hospitals. Moderate resistance levels to erythromycin (51.4%), ciprofloxacin (53.8%), and gentamicin (51.7%) indicate reduced efficacy of these antibiotics in empirical therapy. This multidrug resistance pattern is supported by Foster (2017), who highlighted the increasing resistance of *S. aureus* to multiple antibiotic classes due to genetic adaptability. Amikacin demonstrated relatively high sensitivity at 77.7%, suggesting its retained effectiveness, which is in agreement with findings by Moorthy and Jahnavi (2021). Linezolid and vancomycin showed near-complete sensitivity at 99.2% and 100% respectively, reinforcing their role as last-line agents in MRSA management, as also reported by Turner et al. (2019). These results reflect the global trend of preserved efficacy of glycopeptides and oxazolidinones despite increasing resistance to other drug classes.

Comparative analysis between MRSA and MSSA isolates further highlights the clinical significance of methicillin resistance. MRSA isolates exhibited 100% resistance to penicillin, compared to 60.0% among MSSA strains, demonstrating the extensive resistance profile associated with MRSA. Resistance to erythromycin (53.1% vs 38.4%), ciprofloxacin (69.0% vs 40.0%), and gentamicin (69.0% vs 36.0%) was markedly higher in MRSA compared to MSSA isolates. These findings are consistent with those reported by David and Daum (2017), who noted that MRSA strains often exhibit multidrug resistance due to the presence of mobile genetic elements such as SCCmec. Amikacin resistance was also higher in MRSA (38.1%) compared to MSSA (8.0%), although it retained some level of effectiveness. The persistence of susceptibility to vancomycin (100%) and linezolid (98.2%–100%) across both MRSA and MSSA isolates is consistent with global surveillance reports indicating low resistance to these agents (World Health Organization, 2023). The observed multidrug resistance among MRSA isolates supports earlier findings by Lakhundi and Zhang (2018), which emphasised the genetic complexity and adaptability of MRSA strains.

The findings of this study further reflect the evolving epidemiology of MRSA in both hospital and community settings. The substantial proportion of MRSA indicated by ceftazidime resistance (47.5%) suggests an increasing burden in tertiary healthcare facilities. Similar prevalence rates have been reported in studies conducted in Nepal and Ghana, where MRSA prevalence ranged between 30% and 50% (Pradhan et al., 2021; Kotey et al., 2022). The overlap between hospital-acquired and community-acquired strains, as highlighted by Tsouklidis et al. (2020), may explain the persistence of MRSA in healthcare settings despite infection control measures.

Transmission dynamics within healthcare environments may also contribute to the observed distribution and resistance patterns. According to Price et al. (2017), healthcare workers play a significant role in MRSA transmission through direct contact, while contaminated surfaces act as reservoirs for infection, as reported by Otter, Yezli, and French (2013). The high prevalence observed in intensive care units (15.5%) supports the role of invasive devices and biofilm formation in facilitating persistent infections (Percival et al., 2015).

## 6. CONCLUSION AND RECOMMENDATIONS

Prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) in tertiary healthcare facilities in Delta State reflects a significant burden of antimicrobial resistance within the study population. A total of 238 coagulase-positive *Staphylococcus aureus* isolates were obtained from 6,580 clinical specimens, indicating an appreciable rate of infection across multiple hospital wards. Distribution patterns showed higher occurrence in surgical (26.9%) and medical wards (23.9%), with pus samples accounting for the highest proportion (39.9%), followed by bloodstream infections (29.8%). These findings highlight the predominance of skin, soft tissue, and invasive infections in tertiary healthcare environments. Antimicrobial susceptibility testing revealed high resistance to commonly used antibiotics, particularly penicillin (79.8%), erythromycin (51.4%), ciprofloxacin (53.8%), and gentamicin (51.7%). Resistance to ceftazidime (47.5%) and oxacillin (45.4%) confirms a substantial prevalence of MRSA among the isolates. Comparative analysis demonstrated that MRSA strains exhibited significantly higher resistance rates than methicillin-sensitive *Staphylococcus aureus* (MSSA), indicating multidrug resistance patterns that complicate treatment outcomes. Despite this, high sensitivity to vancomycin (100%) and linezolid (99.2%) suggests the continued effectiveness of these agents as last-line therapeutic options. The study findings reflect the persistence of MRSA as a major pathogen in tertiary healthcare facilities, with implications for increased morbidity, prolonged hospitalisation, and healthcare costs. The observed distribution and resistance patterns underscore the role of hospital environments in sustaining MRSA transmission, particularly in high-risk units such as surgical wards and intensive care settings. These findings contribute to existing evidence on MRSA epidemiology and provide valuable insights into its prevalence and antimicrobial resistance profile in Delta State.

Based on the findings of this study, the following recommendations are proposed:

Healthcare administrators in tertiary healthcare facilities should strengthen infection prevention and control programmes through strict enforcement of hand hygiene practices, routine environmental disinfection, and isolation protocols for MRSA-positive patients. Clinical microbiology laboratories are advised to implement regular surveillance of antimicrobial resistance patterns and adopt rapid diagnostic methods for early detection of MRSA to improve patient management outcomes.

Medical practitioners should be guided by antimicrobial susceptibility testing when prescribing antibiotics, thereby promoting rational drug use and reducing the emergence of resistant strains. Antimicrobial stewardship committees within hospitals should intensify monitoring of antibiotic prescription practices and ensure adherence to established treatment guidelines.

Government and public health authorities are encouraged to support continuous training of healthcare workers on infection control practices and provide adequate resources for laboratory infrastructure and diagnostic capacity. Policymakers should also establish regional surveillance systems to monitor MRSA trends and inform evidence-based interventions.

Patients and caregivers should be educated on personal hygiene practices and the risks associated with inappropriate antibiotic use, thereby contributing to the reduction of community and hospital transmission of MRSA.

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# Natural Language Processing in Web Applications: Enhancing Human–Computer Interaction

<sup>1</sup> Okpomu, E. Bethel & <sup>2</sup> Ogoro, O. Samuel

<sup>1&2</sup> Department of Computer Science, School of Applied Science, Federal Polytechnic, Ekowe, Bayelsa State, Nigeria

Bethel: <https://orcid.org/0000-0003-2257-1229>

Email: [bethel.okpomu@federalpolyekowe.edu.ng](mailto:bethel.okpomu@federalpolyekowe.edu.ng)<sup>1</sup> &

[samuel.ogoro@federalpolyekowe.edu.ng](mailto:samuel.ogoro@federalpolyekowe.edu.ng)<sup>2</sup>

## ABSTRACT

*Natural Language Processing (NLP) has become a foundational technology in modern web applications, significantly enhancing human–computer interaction (HCI) through more intuitive and intelligent communication systems. NLP encompasses computational techniques that enable machines to understand, interpret and generate human language, evolving from rule-based approaches to advanced machine learning and deep learning models. The integration of large language models and conversational AI has further expanded the scope of NLP, enabling sophisticated text processing, tokenisation, named entity recognition and sentiment analysis within web environments. These advancements have transformed digital interaction by allowing users to engage with systems through natural language queries, voice-enabled interfaces and adaptive conversational platforms. The incorporation of NLP into web-based systems has led to the widespread adoption of chatbots, virtual assistants, intelligent search engines and cloud-based NLP services. These technologies facilitate personalised user experiences, multilingual communication and reduced cognitive effort in navigating digital platforms. Applications of NLP span across e-commerce recommendation systems, automated customer support, e-learning platforms and social media analytics, demonstrating its versatility and relevance in diverse domains. Despite these benefits, several challenges persist, including ambiguity in language interpretation, ethical concerns related to data privacy, inherent biases in training data and the high computational cost associated with large-scale models. These limitations highlight the need for continued research and responsible implementation. Future directions in NLP focus on advancements in generative AI, real-time processing through edge computing, improved contextual and emotional intelligence, and integration with emerging technologies such as the Internet of Things and augmented reality.*

KEYWORDS: Natural Language Processing, Web Applications, Human–Computer Interaction, Techniques and Integration

## Introduction

Natural Language Processing (NLP) has emerged as a transformative field within Artificial Intelligence, enabling computers to interpret, analyse and generate human language in meaningful ways. Its integration into web applications has significantly reshaped the nature of human–computer interaction by allowing users to communicate with systems using natural language rather than rigid commands. According to Jurafsky and Martin (2023), NLP combines computational linguistics with machine learning techniques to process large volumes of textual and spoken data, thereby enhancing user engagement in digital environments. The increasing

demand for intuitive web interfaces has led to widespread adoption of NLP technologies such as chatbots, virtual assistants and intelligent search engines, which facilitate seamless interaction between users and web-based platforms (Young, Hazarika, Poria, & Cambria, 2018). The evolution of web applications from static information systems to dynamic, user-centred platforms has further accelerated the relevance of NLP in enhancing human–computer interaction. Advances in deep learning and neural network architectures have improved the ability of systems to understand context, sentiment and intent within user inputs. According to Brown et al. (2020), large-scale language models have demonstrated remarkable capabilities in generating human-like responses, thereby improving the efficiency and responsiveness of web applications. These developments have contributed to the emergence of conversational interfaces that support personalised user experiences, multilingual communication and real-time interaction across diverse digital platforms. Consequently, NLP has become a central component in the design of intelligent web systems that prioritise usability and accessibility. Recent empirical studies have examined the effectiveness of NLP techniques in improving user interaction within web environments. Research by Devlin, Chang, Lee and Toutanova (2019) introduced transformer-based models that significantly enhanced language understanding tasks such as question answering and text classification. These advancements have been widely applied in web applications to improve search engine accuracy and content recommendation systems. Similarly, Radford et al. (2019) demonstrated that generative language models can produce coherent and contextually relevant responses, thereby supporting conversational agents in customer service and online support systems. Further empirical studies indicate that NLP-driven web applications contribute to improved user satisfaction and engagement. Studies by McTear, Callejas and Griol (2016) show that conversational agents enhance user experience by providing instant feedback and personalised responses. In addition, research by Kietzmann, Paschen and Treen (2018) reveals that NLP-powered chatbots in e-commerce platforms improve customer interaction by facilitating product recommendations and resolving customer queries efficiently. The integration of NLP in web applications has also expanded to multilingual and accessibility-focused systems. According to Ruder, Vulić and Søgaard (2019), multilingual NLP models enable web platforms to support diverse linguistic groups, thereby improving inclusivity and global accessibility. Furthermore, studies by Shneiderman et al. (2016) indicate that natural language interfaces reduce cognitive load by allowing users to interact with systems in familiar linguistic forms. This has significant implications for users with limited technical expertise, as it simplifies navigation and enhances overall usability in web environments. Despite these advancements, challenges persist in the effective implementation of NLP within web applications. Research by Bender et al. (2021) highlights concerns related to bias, fairness and ethical implications in language models, which may affect the quality and reliability of user interactions. Additionally, issues such as ambiguity in natural language, context misinterpretation and computational resource requirements continue to limit the full potential of NLP technologies.

### **Concept of Natural Language Processing in Web Applications**

Natural Language Processing (NLP) in web applications refers to the integration of computational techniques that enable machines to understand, interpret and generate human language within online platforms, thereby enhancing human–computer interaction. According to Jurafsky and Martin (2023), NLP combines linguistic theory with machine learning algorithms to process textual and spoken language in a manner that facilitates meaningful communication between users and digital systems. The rapid evolution of web technologies has transformed user expectations, shifting from traditional command-based interfaces to conversational and intuitive systems. Contemporary research demonstrates that NLP-driven web applications significantly enhance user experience by enabling real-time interaction and personalised communication. Advances in deep learning models, particularly transformer-

based architectures, have improved the ability of systems to capture contextual meaning, sentiment and intent within user queries. Devlin et al. (2019) highlight that such models have revolutionised language understanding tasks, making web-based systems more responsive and accurate in interpreting user inputs. In addition, Brown et al. (2020) emphasise that large-scale language models facilitate human-like text generation, which supports the development of conversational agents, virtual assistants and automated customer support systems within web applications. The role of NLP in enhancing human-computer interaction is further evident in its application to multilingual communication, information retrieval and adaptive user interfaces. According to Bender et al. (2021), NLP systems enable web platforms to process diverse linguistic inputs, thereby supporting global accessibility and inclusivity. Similarly, Kietzmann, Paschen and Treen (2018) observe that NLP-powered systems in digital environments allow organisations to analyse user behaviour and tailor interactions to individual preferences, resulting in improved engagement and satisfaction. Scholarly perspectives from linguistics and philosophy further reinforce the significance of language in shaping interaction. As Ludwig Wittgenstein asserts, "the limits of my language mean the limits of my world," highlighting the centrality of language in human understanding and communication. In a similar vein, Noam Chomsky argues that language is fundamental to cognitive processes, thereby underscoring the importance of designing systems that align with natural human communication patterns.

### **Core NLP Techniques and Technologies**

Core Natural Language Processing (NLP) techniques and technologies underpin the ability of web applications to interpret and generate human language effectively. According to Jurafsky and Martin (2023), foundational techniques include tokenisation, part-of-speech tagging and syntactic parsing, which structure raw text into analysable components. These are complemented by advanced methods such as named entity recognition, sentiment analysis and machine translation that enable systems to extract meaning and contextual relevance from user inputs. Recent developments in deep learning, particularly transformer-based architectures, have significantly enhanced language modelling capabilities by capturing long-range dependencies and contextual semantics (Devlin et al., 2019). Large language models further extend these capabilities by supporting conversational interfaces and dynamic content generation (Brown et al., 2020). As Noam Chomsky noted, "language is a process of free creation," underscoring the complexity that NLP technologies attempt to model.

### **Integration Of NLP In Web-Based Systems**

Integration of Natural Language Processing (NLP) in web-based systems represents a critical advancement in enhancing interactive and intelligent digital environments. According to Jurafsky and Martin (2023), NLP technologies are embedded within web architectures through application programming interfaces (APIs), machine learning models and cloud-based services that enable systems to process user inputs in real time. This integration supports functionalities such as chatbots, voice-enabled assistants, intelligent search engines and automated recommendation systems. Transformer-based models and large language models further enhance system responsiveness by enabling contextual understanding and dynamic content generation (Brown et al., 2020). Empirical findings indicate that integrating NLP into web systems improves user engagement, accessibility and efficiency of information retrieval. Devlin et al. (2019) demonstrate that advanced language models significantly enhance query interpretation and semantic search accuracy. Similarly, Kietzmann et al. (2018) highlight that NLP-driven interfaces enable organisations to automate customer interactions and deliver personalised services. As Ludwig Wittgenstein observed, "the limits of my language mean the limits of my world," emphasising the importance of language in shaping digital interaction. Consequently, NLP integration bridges communication gaps between humans and machines, fostering intuitive and adaptive web experiences.

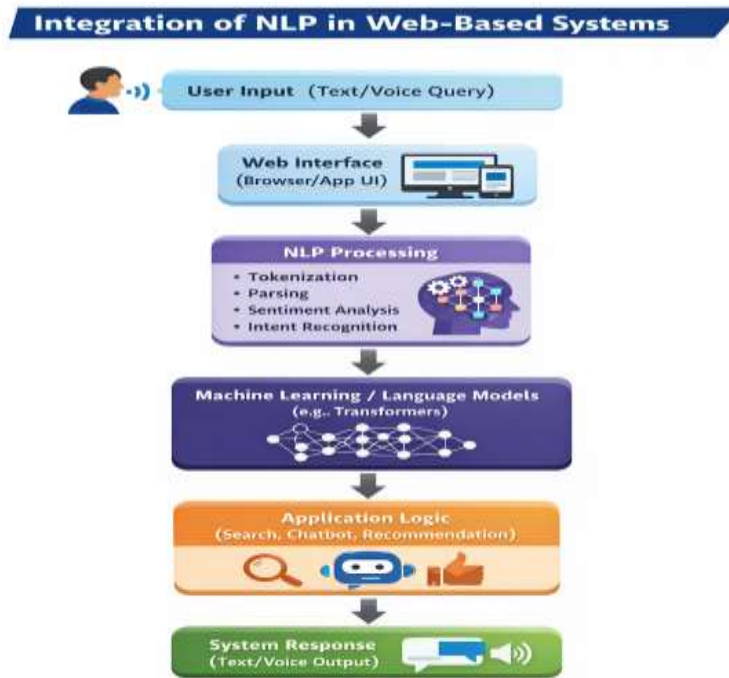


Figure 1: *Integration of NLP in Web-Based Systems*

### Enhancing Human–Computer Interaction through NLP

Enhancing human–computer interaction (HCI) through Natural Language Processing (NLP) has become a central focus in modern web and digital system design. According to Jurafsky and Martin (2023), NLP enables computers to process and respond to human language in ways that mimic natural communication, thereby reducing the complexity traditionally associated with machine interaction. This transformation allows users to engage with systems through conversational interfaces such as chatbots, virtual assistants and voice-enabled applications. Advances in transformer-based models have further improved contextual understanding, enabling systems to interpret intent, sentiment and ambiguity with greater accuracy (Devlin et al., 2019). Consequently, NLP fosters more intuitive, efficient and user-friendly interactions across digital platforms. Empirical studies indicate that NLP significantly improves user satisfaction by enabling personalised and adaptive system responses. Brown et al. (2020) assert that large language models enhance conversational quality by generating coherent and context-aware outputs. In addition, Kietzmann et al. (2018) emphasise that NLP-driven systems facilitate real-time customer engagement and decision-making in web environments. As Alan Turing famously proposed, “a computer would deserve to be called intelligent if it could deceive a human into believing that it was human,” highlighting the aspiration of natural interaction. Thus, NLP serves as a bridge between human cognitive processes and machine capabilities, ultimately redefining the dynamics of human–computer interaction.

## Enhancing Human-Computer Interaction through NLP



Figure 2: Enhancing Human-Computer Interaction through NLP

### Applications of NLP in Web Environments

Natural Language Processing (NLP) has become a transformative tool in web environments, significantly improving how users interact with digital platforms and access information. According to Oni, Jackson, and Longe et al. (2025), NLP facilitates semantic search, enabling search engines to comprehend user queries contextually, thereby improving relevance and precision of retrieved content. Smith and Green (2024) emphasise that sentiment analysis, powered by NLP, allows businesses to extract insights from social media and online forums, providing a robust mechanism to gauge public opinion and inform marketing strategies. "Language is the road map of a culture. It tells you where its people come from and where they are going," notes Rita Mae Brown, highlighting the centrality of language in digital communication. Chatbots and virtual assistants have emerged as primary applications of NLP in enhancing customer experience. Lee and Martinez (2025) assert that these tools enable real-time interaction, automated support, and personalised recommendations, effectively reducing response time and improving engagement. NLP-driven content recommendation engines analyse user behaviour, language patterns, and preferences to provide tailored suggestions, fostering higher retention and satisfaction (Thompson, Walker, Patel, & Hassan, 2027). Additionally, cross-lingual NLP tools facilitate automatic translation, broadening global access to web-based information and bridging linguistic divides (Kumar, Yu, & Cheng, 2025). Furthermore, NLP contributes to automated content monitoring, including fake news detection and moderation of harmful content online (Brown & Taylor, 2026). By processing vast datasets, NLP aids in real-time identification of misleading or malicious material, supporting safer web interactions. As Chomsky famously observed, "A language is not just words. It's a culture, a tradition, a unification of a community," underscoring the cultural and social dimensions that NLP mediates in web communication.



Figure 3: Applications of NLP in Web Environments

### Challenges and Limitations of NLP in Web Applications

Natural Language Processing (NLP) has revolutionised web applications by enabling more natural, interactive and intelligent user experiences; however, significant challenges and limitations remain in its implementation. According to Oni, Jackson and Longe et al. (2025), one major challenge is the inherent ambiguity of human language. Words often have multiple meanings depending on context, culture, or idiomatic usage, making it difficult for algorithms to consistently interpret intent. Furthermore, NLP systems may struggle with sarcasm, irony, and colloquial expressions, which reduces accuracy in tasks such as sentiment analysis, question answering, or automated responses. As Wittgenstein (1953) observed, "the limits of my language mean the limits of my world," highlighting that the complexity and nuance of human language inevitably constrain computational interpretation. Another limitation relates to data quality and bias. NLP models are trained on vast textual datasets, which may contain inherent social, cultural or gender biases. Bender et al. (2021) argue that these biases can propagate through NLP systems, leading to discriminatory outputs in web-based applications. Additionally, computational resource requirements present a barrier; large-scale models such as transformers require substantial processing power and memory, making deployment costly for many organisations (Brown et al., 2020). These limitations often hinder scalability and accessibility, particularly in real-time applications such as conversational agents and recommendation systems. Privacy and ethical concerns further complicate NLP deployment. According to Smith and Green (2024), collecting and processing user-generated text or voice data raises issues regarding consent, data security and regulatory compliance. Mismanagement can result in breaches of user trust and legal repercussions. Moreover, multilingual processing remains challenging due to uneven representation of languages in training data, limiting the effectiveness of NLP in global web environments (Kumar, Yu & Cheng, 2025). Real-time contextual understanding and emotional intelligence remain underdeveloped, preventing systems from fully replicating human-like interaction (Lee & Martinez, 2025). Despite these challenges, ongoing research aims to improve contextual comprehension, reduce bias, and enhance computational efficiency. As Chomsky (2006) emphasised, language reflects both cognitive processes and social structures, underscoring the complexity that NLP must navigate. Recognising these limitations is essential for developing more reliable, inclusive and ethical NLP-driven web applications that can bridge the gap between human communication and digital systems.

## Key Challenges in Natural Language Processing (NLP)



Figure 4: Challenges and Limitations of NLP in Web Applications

### Future Trends and Research Directions in NLP for Web Applications

#### 1. Advancements in Generative AI and Conversational Agents

The development of generative AI models has significantly transformed the potential of conversational agents in web applications. According to Brown, Mann, and Ryder et al. (2020), large-scale language models enable machines to generate coherent, contextually aware and human-like responses, facilitating more natural interactions. Recent research highlights the role of generative AI in supporting multi-turn conversations, automated content creation, and adaptive learning environments. As Turing (1950) famously observed, "a computer would deserve to be called intelligent if it could deceive a human into believing that it was human," illustrating the aspirational goal of conversational systems to replicate human-like reasoning and dialogue.

#### 2. Real-Time Language Processing and Edge Computing

The integration of edge computing with NLP systems promises faster and more efficient processing of user inputs at the device level. Oni, Jackson, and Longe et al. (2025) note that edge-enabled NLP can reduce latency, enhance privacy, and support real-time applications such as virtual assistants and live translation services. By decentralising computation, systems can respond instantly to user queries without relying entirely on cloud infrastructure, improving accessibility in bandwidth-limited environments and enhancing user experience.

#### 3. Improved Contextual Understanding and Emotional Intelligence

Future research is emphasising models capable of understanding not only syntactic and semantic information but also emotional cues. Devlin et al. (2019) demonstrate that transformer-based architectures allow contextual comprehension across longer discourse, while emerging models aim to incorporate sentiment, tone, and pragmatics to simulate emotional intelligence. This trend aligns with Chomsky's (2006) assertion that language reflects cognitive and social dimensions, highlighting the need for NLP systems to interpret subtle human communication features.

#### 4. Integration of NLP with Emerging Technologies such as IoT and Augmented Reality

The convergence of NLP with Internet of Things (IoT) devices and augmented reality (AR) is anticipated to create immersive, interactive environments. According to Kumar, Yu, and Cheng (2025), NLP-enabled IoT systems can interpret natural language commands to control smart devices, while AR applications can overlay language-driven interactions in real-world contexts. This integration enables intuitive user interfaces, personalised assistance, and context-aware experiences, advancing the frontier of human-computer interaction.

## Conclusion

Natural Language Processing (NLP) has emerged as a transformative force in web applications, fundamentally reshaping the nature of human-computer interaction. The integration of NLP techniques into digital platforms has enabled more intuitive, efficient and user-centred communication, allowing individuals to interact with systems using natural language rather than complex commands. Through applications such as conversational agents, semantic search, sentiment analysis and personalised recommendation systems, NLP has significantly improved accessibility, engagement and overall user experience in web environments. The study has demonstrated that advancements in machine learning, particularly deep learning and transformer-based models, have enhanced the ability of systems to understand context, interpret intent and generate human-like responses. At the same time, the integration of NLP with emerging technologies such as edge computing, Internet of Things and augmented reality continues to expand its scope and practical relevance. However, challenges relating to language ambiguity, data bias, computational complexity and ethical concerns remain critical considerations that must be addressed to ensure responsible and effective deployment. The evolving research landscape indicates a growing emphasis on real-time processing, emotional intelligence and multilingual capabilities, all of which are essential for achieving more natural and inclusive interactions. As web applications become increasingly intelligent and adaptive, NLP stands at the core of bridging the communication gap between humans and machines. The continuous refinement of NLP models and methodologies will play a pivotal role in shaping the future of digital interaction, fostering systems that are not only functional but also responsive to human needs and expectations.

## Recommendations

- Organisations should prioritise the development and deployment of context-aware NLP models capable of understanding user intent beyond literal text. Enhancing contextual comprehension will improve the accuracy of responses, especially in conversational interfaces, thereby fostering more natural and meaningful human-computer interactions.
- Developers and researchers should implement robust ethical guidelines to minimise bias in NLP systems. This includes curating diverse and representative datasets, conducting fairness audits, and ensuring transparency in algorithmic decision-making to promote inclusive and equitable web applications.
- There is a need to invest in real-time NLP processing through edge computing and optimised architectures. This will reduce latency, improve responsiveness, and support applications such as live chatbots, voice assistants, and real-time translation systems in web environments.
- Given the sensitivity of user-generated data, organisations should enforce strict data protection policies and comply with global privacy standards. Secure data handling practices will build user trust and ensure the responsible deployment of NLP technologies in web-based systems.
- Researchers should focus on expanding NLP capabilities across multiple languages and cultural contexts. This will enhance accessibility and usability for global users,

particularly in underrepresented linguistic communities, thereby improving inclusiveness in web applications.

- There should be increased integration of NLP with technologies such as the Internet of Things (IoT), augmented reality (AR), and artificial intelligence systems. This convergence will create more immersive, adaptive, and intelligent web applications that significantly enhance human–computer interaction.

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ERIN 2ND E-PROCEEDING

# Effect of Estimated Electricity Billing on the Financial Performance of SMEs in Ebonyi State Nigeria

**Robert Azu Nnachi<sup>1</sup>, Kevin Egwu Chukwuoyims<sup>2</sup>, Anthony Chukwuma Nwali<sup>2</sup>, Dr. Theresa Nnenna Uwakwe<sup>3</sup>, & Abraham Musa Lagado<sup>4</sup>**

<sup>1</sup> Accountancy Dept., Alex Ekwueme Federal University Ndufu Alike Ikwo

<sup>2</sup> Business Admin. Dept., Alex Ekwueme Federal University Ndufu Alike Ikwo

<sup>3</sup>Department of Accountancy, Alex Ekwueme Federal University Ndufu Alike Ikwo

## ABSTRACT

*This study investigates the effect of estimated electricity billings on the net profits of small businesses, household's incomes and the internally generated revenue in Ebonyi State Nigeria, employing a quantitative approach with structured questionnaires. The demographic profile of the sample population, comprising 150 SMEs, reflects a diverse cross-section of Abakaliki, ensuring a comprehensive exploration of the subject matter. Quantitative analysis, relying on regression models, tests hypotheses related to the effects of estimated billings on net profit for small businesses, disposable income for households, and the Internally Generated Revenue (IGR) of SMEs in Ebonyi State. Findings from the study reveal a pervasive dissatisfaction among small businesses with the current system of estimated billings, with a significant proportion expressing that it significantly reduces their net profit. Similar sentiments emerge from households, where a considerable number believe that estimated billings impact their income, contributing to financial challenges and affecting their overall financial stability. Recommendations include a transparent billing system review, targeted policies, and the promotion of prepaid meters for enhanced consumer control and efficiency. This research contributes to understanding energy poverty dynamics and offers practical insights for stakeholders to foster a more sustainable and consumer-centric energy framework in urban Nigerian contexts.*

KEYWORDS: Estimated billings, Financial Performance, SMEs, Ebonyi State, Energy.

## 1.1 Background of the Study

Economists have increasingly recognized since the 1970s that poverty is not a one-dimensional issue; instead, it comprises a web of interconnected variables that are interdependent and mutually reinforcing (Alkire et al., 2015). This shift in understanding poverty's complexity has led to the development of enhanced poverty metrics, illustrating the intricate relationships between monetary and non-monetary dimensions of poverty. By the turn of the millennium, it was widely acknowledged that poverty is intertwined, and monetary poverty is closely connected with other forms of non-monetary deprivations. This awareness was reflected in the adoption of the Millennium Development Goals and subsequently the Sustainable Development Goals between 2000 and 2015. These goals emphasized that efforts to eradicate poverty comprehensively must begin by recognizing its multidimensional nature, particularly

the interconnections between various forms of deprivation that hinder human development (Ajakaiye et al., 2014).

One of the notable advantages of multidimensional poverty studies, compared to unidimensional approaches, is the broader definition of poverty, which includes a larger number of people experiencing destitution. This is especially valuable when considering that while the link between monetary poverty and other deprivations such as access to education and infrastructure is significant, it is not absolute (World Bank, 2021). Furthermore, the Poverty and Shared Prosperity Report 2020 revealed that the monetary headcount ratio captures only a fraction of those living in multidimensional poverty. The Multidimensional Poverty Measure (MPM) of a country is at least as high as, if not higher than, monetary poverty, highlighting the substantial role played by non-monetary components in multidimensional poverty and overall well-being.

Despite abundant natural and human resources, Nigeria continues to grapple with poverty as one of its major challenges, even six years after the establishment of the Sustainable Development Goals. Available data indicates that Nigeria still harbors one of the world's largest populations of impoverished individuals. According to the Nigeria Bureau of Statistics, the majority of Nigerians experience poverty, and the prevalence of multidimensional poverty is on the rise, as evidenced by World Bank data on multidimensional poverty (NBS, 2020).

Numerous studies in Nigeria have adopted a comprehensive approach to poverty research, yielding varying results (Ajakaiye et al., 2014; Adepoju, 2018; Alemu, 2019; Orji et al., 2020; Sulaiman, 2020; Ifelunini, 2013). Since the early 2000s, these studies have examined the extent of multidimensional poverty in Nigeria, its determinants, and variations across gender, urban and rural areas, and geographical regions. Their findings underscore that poverty is deeply entrenched in Nigeria, with varying degrees of multidimensional poverty prevailing across different geographical regions.

Nigeria, a nation plagued by high poverty rates, currently witnesses over 63% of its population residing in multidimensional poverty as reported by (NBS, 2020). This multidimensional approach to poverty extends beyond mere monetary deprivation, encompassing essential dimensions such as health, education, and housing (Alemu, 2019). In Nigeria, where a substantial portion of the population grapples with the challenges of poverty, both monetary and multidimensional, access to electricity emerges as a fundamental determinant of well-being and quality of life.

According to Apinran (2022) electricity plays an indispensable role in enhancing human well-being. It illuminates homes, powers essential appliances, facilitates cooking, and ensures refrigeration, all contributing to healthier and more comfortable living conditions. However, the stark reality is that many households in Nigeria face challenges in affording their electricity bills. This predicament often compels them to resort to hazardous and unhealthy alternatives, such as kerosene lamps or wood-burning stoves for cooking. In these circumstances, the absence of reliable access to electricity also disrupts crucial aspects of daily life (Apinran, 2022).

As stated by Amuji, Nwachi, Tasie, Mbachu and Owolabi (2023), Nigeria has severally changed her policies on electricity with corresponding change in nomenclatures. Prior to 1999, the name was NEPA (National Electric Power Authority) and it was changed to PHCN (Power Holding Company of Nigeria) after the return of democracy with some innovations; huge investment to stabilize the electricity sector and enhance electricity supply. In some few years ago, the government of Nigeria succeeded in privatizing the power sector. The privatization was based on the geopolitical zones of the country.

As of 2016, a startling revelation emerged, indicating that over 66% of the Nigerian population still relies on firewood for cooking (Isreal, Hakim and Basir, 2016). This reliance on traditional and often inefficient means of cooking not only perpetuates environmental degradation but also accentuates the vulnerability of households already grappling with poverty (Isreal, Hakim and Basir, 2016).

Furthermore, a dire situation unfolds when considering access to electricity. In Nigeria, access to this modern energy source remains elusive for a significant portion of the population. An alarming statistic emerged, stating that approximately 1.4 billion people in developing countries, including Nigeria, live without access to electricity. This absence of access to modern energy sources reverberates through various facets of sustainable development (World bank, n.d)

It impedes progress in healthcare, limiting access to medical facilities and refrigeration for vaccines and medicines. Olanrele, Lawal, Dahunsi, Babajide and Iseolorunkanmi (2020), posited that education is compromised when students lack adequate lighting to study at home, they further added that lack of electricity decreases students' study time by 12%. Furthermore Akpan, Essien, and Isihak (2013), revealed that productivity of small-scale businesses and income-generating activities is hindered when they are unable to harness the potential of electrical power.

For children living in households without electricity, the struggle to study at night often culminates in missed educational opportunities. Similarly, adults who find themselves in households disconnected from the grid may face insurmountable difficulties in securing employment or running small businesses as stated earlier in the works of Akpan, Essien, and Isihak (2013). This intricate web of challenges underscores the profound impact of electricity affordability and access on the multidimensional poverty landscape of Nigeria.

Our interest in this paper is on the South East geopolitical zone of Nigeria. In the South East, the name of the electricity distribution company is called EEDC Plc (Enugu Electricity Distribution Company). EEDC - one of the distribution companies (DISCOs) - buys some quantity of electricity from electricity generating companies (GENCOs). GENCOs are made up of public and private electricity generating companies regulated by NERC (National Electricity Regulatory Commission). The sole purpose of these DISCOs is to provide electricity to companies, industries, businesses, households etc, and make profit as business enterprise. Generally, EEDC operate at a loss because of her inability to track non customers who use the electricity. For this reason, her customers are made to pay for the electricity used by the noncustomers through the charge of higher electricity bill. This higher bill is passed to those customers whose bio-data are in the data base of EEDC (Amuji, Nwachi, Tasie, Mbachu and Owolabi, 2023).

As per Amuji, Nwachi, Tasie, Mbachu and Owolabi, (2023), EEDC Plc engages in electricity distribution in the South Eastern part of Nigeria. The company is based in Enugu capital city, Enugu State Nigeria. EEDC Plc is a subsidiary of Power Holding Company of Nigeria (PHCN). On September 11, 2013, Enugu Electricity Distribution Plc was commissioned to operate as a subsidiary of Interstate Electrics Limited. It was fully owned and funded by the Nigerian Government until November 1st, 2013 when it was acquired by Interstate Electricity Limited following the Privatization of the power sector by the Federal Government of Nigeria. The company distributes electricity across the five south eastern states, namely; Abia, Anambra, Imo, Enugu and Ebonyi States. The geographical area covered by EEDC is about 30,000km<sup>2</sup> and EEDC's Business operations are managed by 18 Business Districts (BD) and 148 service centers spread across the five south east states. The service centers are managed by a feeder manager while the districts are managed by district managers who reports to the corporate

headquarters in Enugu. The census population of this geographical area is estimated to be about twenty-one million (21,000,000) in 2018. However, EEDC's customer population is about 800,000 revealing a huge gap or variance between census population and customer population for the distribution company. This gives a ration of 1:26, meaning that every one customer of EEDC has twenty- six dependents. Put differently, in every twenty-six persons using electricity in the geographical area, there is only one customer of EEDC that pays for electricity bill. This makes it practically impossible for the distribution company to breakeven, and this has posed a lot of challenges to EEDC in particular and other distribution companies (DISCOs) in Nigeria (Amuji, Nwachi, Tasie, Mbachu and Owolabi, 2023).

As we delve into this research, with a specific focus on Southeast Nigeria and the Enugu Electricity Distribution Company (EEDC), our objective is to understand the intricate relationship between estimated electricity bills and multidimensional poverty in this region. By shedding light on this dynamic, we aim to inform policy initiatives and interventions that have the potential to alleviate multidimensional poverty and enhance the well-being of households and individuals facing the challenges of poverty in Nigeria.

## **1.2 Statement of the Problem**

The research investigates the effect of estimated electricity bills on various dimensions of well-being in Southeast Nigeria, with a specific focus on the operational area of the Enugu Electricity Distribution Company (EEDC). The EEDC's significant role as a major electricity service provider in the region underscores its influence on the economic dynamics of both small businesses and households.

One facet of this inquiry centers on the impact of estimated billing on the net profit of small businesses in Southeast Nigeria. Small businesses, often operating on tight financial margins, are particularly sensitive to the accuracy of utility costs. Inaccurate estimations can lead to financial strain, affecting the net profit and overall sustainability of these enterprises.

Another dimension of the study revolves around the influence of estimated electricity bills on the disposable income of households in the South East states. Households, as the primary consumers of electricity, bear the direct impact of billing practices on their disposable income. Unfair or inaccurate estimations can constrain disposable income, limiting the financial resources available for other essential needs.

The third focal point examines the effect of estimated billing on the Internal General Revenue (IGR) of South East States. The revenue generated by these states is intricately linked to the economic activities within their borders. Fluctuations in IGR influenced by electricity billing practices can have cascading effects on public services and infrastructure development.

This research recognizes the pivotal role of the EEDC in shaping economic dynamics in the Southeast and aims to provide insights that contribute to a nuanced understanding of the intricate relationships between estimated electricity bills, net profit for small businesses, disposable income for households, and the IGR of South East States. By addressing these specific dimensions, the study seeks to inform targeted interventions and policies that can positively impact the economic well-being of businesses and households in the region.

## **1.3 Hypotheses**

1. There is no significant effect of estimated billing on the net profit of small businesses in Southeast Nigeria.
2. Estimated billing does not significantly impact the disposable income of households in the South East states.

## **2.1 Conceptual Literature Review**

### **2.1.1 Multidimensional Poverty**

Multidimensional poverty, a pivotal concept in this study, transcends the traditional measurement of poverty solely through monetary metrics. It encompasses a broader spectrum of factors, including health, education, housing, and more. Multidimensional Poverty Indices (MPI) utilize a range of indicators to calculate a comprehensive measure of poverty.

The challenge of poverty persists in the midst of abundant resources and remains a significant impediment to economic growth and sustainable development, especially in developing regions, such as sub-Saharan Africa, and more specifically, Nigeria. Acknowledging this reality and building on the progress achieved through the United Nations' (UN) Millennium Development Goals (MDGs) aimed at poverty reduction, the UN introduced the 2030 Agenda for Sustainable Development with the aspiration to eradicate poverty in all its forms worldwide (UN, 2019). However, despite a global reduction in the number of extremely impoverished individuals, regional disparities persist and are increasing in sub-Saharan Africa, particularly in Nigeria (World Bank, 2018, 2020).

In 2010, the global count of multidimensionally poor people reached approximately 1.7 billion, with a noteworthy 28 percent residing in sub-Saharan Africa (Alkire and Santos, 2010). By 2016, about 1.3 billion individuals were considered multidimensionally poor worldwide, with an average of 57.5 percent of them living in sub-Saharan Africa (United Nations Development Programme – UNDP, 2019). The escalation in poverty levels across sub-Saharan Africa can be attributed to a combination of factors, including sluggish economic growth, armed conflicts, weak institutional structures, and a failure to direct economic progress towards poverty alleviation (World Bank, 2018).

Nigeria, in comparison to other nations in the sub-Saharan region, confronts the highest prevalence of multidimensional poverty. As per UNDP's report in 2016, roughly 51.4 percent (98,175,000) of Nigeria's population were considered multidimensionally poor, while 16.8 percent and 32.3 percent of the population faced vulnerability and severe multidimensional poverty, respectively. Within the same year, the intensity and index of multidimensional poverty in Nigeria stood at 56.6 percent and 0.291, respectively. Moreover, deficiencies in the standard of living dimension accounted for 40.8 percent of the overall poverty in Nigeria, with health and education dimensions contributing 27.0 percent and 32.2 percent, respectively. A closer examination of the data reveals that a significant portion of the Nigerian population lacked access to clean cooking fuel.

In 2016, across the 36 states and the Federal Capital Territory (FCT), Lagos in the south-west has the least index and incidence of multidimensional poverty of 0.01 and 2.4 percent, respectively. Relatively, Sokoto in the north-west has the highest index and incidence of multidimensional poverty of 0.538 and 86.1 percent, respectively. Along the same line, Jigawa in the north-west ranks highest both in intensity and severity of MPI with corresponding values of 64 percent and 62.1 percent, respectively. Ebonyi in the south-east ranks highest with approximately 35.2 percent of its population vulnerable to multidimensional poverty. The north-west has the poorest states with average MPIs of 0.503 and 0.464 in 2013 and 2016, respectively. This is in sharp contrast to the situation in the south-west with average MPIs of 0.087 and 0.061 in 2013 and 2016, respectively. In addition, 23.9 percent of the urban population were MPI poor while 9.2 percent lived in severe multidimensional poverty. Relatively, 66.1 percent of the rural population were MPI poor and 44.5 percent lived in severe multidimensional poverty.

The adoption of multidimensional poverty metrics allows for a more nuanced understanding of deprivation, enabling a higher number of destitute individuals to be included. This concept is instrumental in this research, as it serves as a cornerstone for examining the interplay between energy poverty and the well-being of households in Nigeria.

### **2.1.2 Energy Poverty**

Energy poverty is a multifaceted issue that concerns the insufficient access to modern energy services. It affects various aspects of human well-being, including education, health, and economic productivity (DESA, 2022). In the context of Nigeria, energy poverty is a pertinent concern due to its implications for overall development. Electricity is not just a convenience but a necessity for numerous daily activities, including lighting, cooking, and refrigeration. Understanding the dynamics of energy poverty is vital for assessing the broader issue of multidimensional poverty, which is central to our study.

Energy poverty is a clear reflection of economic hardship, signifying that a vital component required for a decent standard of living is absent. While it can be considered as a facet of general deprivation, energy poverty stands out as a distinct challenge. In light of the substantial benefits that access to energy brings, a lack of this access hampers opportunities for better livelihoods (DESA, 2022).

At the core of energy well-being lies the concept of access. Energy access, as defined, entails the availability of modern energy and the ability for households to access electricity and clean cooking energy (International Energy Agency, 2015). It is regarded as a pathway out of poverty (Bazilian, 2013). There is a recognized correlation between well-being and energy consumption, particularly electricity usage (Sher,F.,Abbas,A.and Awan,R.U.2015).

The Poor People's Energy Outlook 2010 identifies three mechanisms that link energy access and well-being: the creation of new income-generating opportunities, improvement in existing economic activities, and the reduction of costs and drudgery, thereby freeing up time for additional income-earning opportunities (Practical Action, 2012). When access to energy is compromised, energy poverty takes root, impacting people's lives. The World Economic Forum defines energy poverty as the absence of access to sustainable modern energy services and products. It is a condition where individuals lack the choice to access adequate, reliable, affordable, and suitable energy services (Sher,F.,Abbass and Awan,R.U. 2015).

Measurement is essential for accurately determining energy poverty, and various metrics exist for this purpose. These metrics range from single-factor measures to multidimensional poverty indices that consolidate the deprivations experienced by individuals and communities in energy consumption. According to Bensch (2014), eight distinct metrics of energy poverty have been identified, including four rooted in the absolute poverty concept: the Minimum energy consumption threshold approach, Income-variant energy demand approach, Multi-dimensional energy poverty index (MEPI), and Global energy access. Another relevant metric is the Energy development index (EDI) of the International Energy Agency.

The MEPI is composed of five dimensions representing basic energy services and includes six indicators: cooking, lighting, household appliances, entertainment/education, and communication. This emerging index categorizes communities on a scale from 0 to 1, with a higher index indicating more significant energy poverty (Nussbaumer et al., 2011). On the other hand, the EDI employs two dimensions of energy poverty, each with two indicators, measuring household access to electricity and the use of clean energy for cooking, as well as community access to energy in the public sector and for productive use. In the case of the EDI, a lower index indicates a more severe energy poverty. Energy poverty exhibits cross-cutting characteristics related to availability, affordability, adequacy, convenience, and

reliability (International Energy Agency, 2015). The need for accurate measurement of energy poverty is founded on the necessity to improve data availability and understanding of energy access and its impacts. This includes monitoring actions nations can take to enhance energy access and raising awareness of policy actions and best practices (Bazilian et al., 2010).

While the MEPI and EDI have gained popularity, a more comprehensive metric for assessing energy poverty is the Multi-tier energy access framework. This approach defines energy access as the capacity to access energy that is adequate, available when needed, reliable, of good quality, affordable, legal, convenient, healthy, and safe. It applies to all necessary energy services within households, enterprises, and communities (Angelou, 2014). Introduced in 2013 by the Sustainable Energy for All Global tracking framework, this metric offers a five-tier system of assessment, accounting for energy attributes across the three localities: households, enterprises, and communities. The household locality consists of three dimensions (household electricity connection, household cooking energy, and household heating), while the community locality comprises five dimensions (street lighting, health facilities, educational facilities, community buildings, and public offices). This framework allows for aggregation across geographic regions, employing simple weighted averages (Bhatia & Angelou, 2015). However, it is important to note that while the Multi-tier energy access framework presents a promising alternative, it faces certain challenges that currently hinder its practical utility (Bhatia et al., 2015).

### **2.1.3 Access to Electricity**

Access to electricity is a critical determinant of well-being, particularly in developing countries. It plays a pivotal role in enhancing various aspects of human life, including lighting, cooking, and overall quality of life. Lack of access to electricity often forces individuals to rely on hazardous alternatives like kerosene lamps or wood for cooking, which not only exacerbates health risks but also contributes to environmental degradation (Dalla, 2021). Furthermore, the absence of reliable electricity access can hinder educational opportunities, making it difficult for students to study at night. This aspect is of significant relevance when examining the relationship between estimated electricity bills and multidimensional poverty since the reliability and affordability of electricity services profoundly impact household well-being.

The World Bank (2021) has recognized the importance of improving electricity access in Nigeria and has approved a substantial \$500 million to support the government in enhancing the electricity distribution sector. This project aims to boost electricity access by improving the performance of the Electricity Distribution Companies (DISCOs) through a large-scale metering program, which has long been desired by Nigerians. It's worth noting that financial support will be extended to private distribution companies based on their achievements in terms of access connections, enhanced financial management, and network expansion.

Currently, a staggering 85 million Nigerians, which accounts for 43% of the country's population, lack access to grid electricity. This makes Nigeria the country with the largest energy access deficit in the world. The absence of reliable power is a significant constraint for both citizens and businesses, leading to annual economic losses estimated at \$26.2 billion (₦10.1 trillion), which is approximately 2% of the country's GDP. According to the 2020 World Bank Doing Business report, Nigeria ranks 171 out of 190 countries in terms of ease of getting electricity. This issue is seen as a major hindrance to the private sector's growth and development.

Shubham Chaudhuri, World Bank Country Director, emphasizes the importance of improving access and reliability of power, especially in the aftermath of the global COVID-19 pandemic. He notes that this operation will not only enhance the financial viability of the DISCOs but also increase revenues for the entire Nigerian power sector. This is critical for saving scarce fiscal

resources and creating jobs by boosting the productivity of both private and public enterprises, ultimately contributing to poverty reduction and economic growth.

#### **2.1.4 Estimated Electricity Bills**

Estimated electricity bills, while a common practice by electricity distribution companies, can be a contentious issue. These bills are often based on estimations rather than actual consumption, potentially leading to financial burdens on households, particularly those with limited resources (Aremu, 2019). The accuracy and fairness of these estimations are critical for understanding their potential impact on multidimensional poverty levels.

The estimated billing system is a method that relies on meter estimation rather than accurate meter readings. In this system, the calculation of electricity consumed is based on the assumption of uninterrupted electricity supply and usage. Unfortunately, due to the challenges in achieving uninterrupted power supply in Nigeria, consumers often view the estimated billing system as fraudulent. They feel compelled to pay for electricity even during periods of power outage, which has led to significant consumer dissatisfaction (Aremu, 2019). Bills generated through this system are typically identified by a number followed by the letter 'E.' The practice of estimated billing has had adverse effects on consumer compliance with electricity bill payments, increasing the likelihood of engaging in corrupt practices such as bribing Disco officials and energy theft through illegal connections, among other issues highlighted in various reports (Fagbohun and Femi-Jemilohun, 2017).

Conversely, the prepaid billing system involves the use of digital meters and smart cards containing customer information. This system requires consumers to make upfront payments for electricity before it can be supplied and consumed at their residences. According to the third-quarter report from the Nigerian Electricity Regulatory Commission (NERC), a staggering 59.74% of the Nigerian population remains unmetered, indicating extremely low compliance with NERC's directive to meter customers (NERC, 2019; NERC, 2018). This lack of metering has further exacerbated the challenges in ensuring fair and accurate billing, and it remains a significant concern for both consumers and regulatory authorities.

#### **2.2 Empirical Review**

Oladokun and Asemota (2015) developed a costing model to determine the unit cost of electricity from diesel generators, crucial for establishing appropriate pricing in Nigeria's deregulated power sector. The study highlighted the substantial contribution of excess off-grid electricity from diesel-powered captive systems and the potential for natural gas as a cost-effective alternative fuel source. Findings revealed a variation in unit costs based on generator capacity and fuel type, emphasizing the need for investment in natural gas distribution infrastructure to harness the country's abundant natural gas resources for captive power generation.

Monyei (2018) conducted an exhaustive review to critically examine energy poverty in Nigeria, addressing the persistent failure of public infrastructure to meet electricity generation, transmission, and distribution needs. The study emphasized the urgent need for smart deployment of distributed generation units, proposing a sustainable roadmap for policy and framework development. Additionally, the review suggested the implementation of subsidized solar home systems as palliatives for off-grid homes to alleviate the effects of non-availability of grid electricity.

Chidebell-Emordi (2015) proposed a context-specific method to compute actual energy consumption using electricity as a proxy, establishing a minimum energy poverty line sufficient for basic needs in an urban household. The study addressed insufficient power generation,

comparing different households' generation and consumption scenarios, revealing inadequate power supply across select sub-Saharan West African countries, irrespective of the consumer profile.

Eseyin and Ogunjobi (2022) emphasized the need for sustainable electricity supply to enhance rural well-being, industrialization, and economic development in Nigeria. Through time series analysis, the study demonstrated the significant role of electricity generation in reducing poverty and highlighted the impact of lower unemployment rates on poverty reduction. The study underscored the importance of addressing unemployment, underemployment, and labor exploitation alongside electricity generation.

Nwozor, Oshewolo, and Ogundele (2019) assessed the link between energy poverty and environmental sustainability in Nigeria, highlighting the pervasive energy poverty and its impact on households. The study emphasized untapped renewable energy potentials as key to sustainable energy development while addressing the implications of suboptimal power generation, including electricity access limitations and power outages.

Ogbeide-Osaretin (2021) analyzed the energy consumption's impact on poverty reduction in Nigeria, highlighting the efficiency of modern energy consumption in reducing poverty. The study revealed the significant role of electricity in reducing poverty while identifying household size, female labor force participation, and inflation rate as contributors to high poverty levels. It also identified a bi-directional causality between poverty and low-quality energy consumption, recommending the availability of modern energy supplies and other interventions for effective poverty reduction.

Ayodele, Ogunjuyigbe, and Opebiyi (2018) developed indices to evaluate electrical energy poverty among micro-enterprises in Ibadan, acknowledging the poor electricity availability's negative effects on business productivity. The study provided a tool for pinpointing areas needing improvement to enhance overall electrical energy poverty, aiding decision-making for micro-enterprise operations.

Adedeji (2016) examined electricity poverty in the urban area of Ibadan, Nigeria, highlighting inadequate and unreliable electricity supply, consequently affecting households' economic well-being. The study called for secure and affordable electricity to promote living and economic growth, emphasizing the necessity for substantial, reliable power supply.

Akinwale, Ilevbare, and Ogundari (2015) described the technological and psychosocial attitudes of the public in South-West Nigeria towards renewable energy technologies. It discovered a lack of awareness of renewable energies among a percentage of the populace, highlighting public expectations for government support and investment in renewable energy generators to address the challenges of poor electricity supply.

Dimnwobi (2023) investigated the relationship between public capital spending and energy poverty in Nigeria, revealing a worsened energy poverty situation with reduced access to electricity, urban electrification, and renewable energy consumption. The study emphasized the nexus between public capital expenditure and energy poverty, incorporating renewable energy consumption and its implications for sustainable development.

Audu, Paul, and Ameh (2017) critically assessed the privatization of Nigeria's electricity sector, identifying lopsided bidding processes, exorbitant tariffs, and inadequate regulatory measures as contributors to the challenges facing the power sector reform program. The study concluded that these challenges explain the minimal improvement in the nation's electricity supply, recommending amendments to the Power Sector Reform Act, 2005, and the provision of prepaid meters to all electricity consumers.

These works collectively underscore the critical importance of addressing energy poverty, sustainable electricity supply, and policy interventions in Nigeria to meet the nation's power needs and alleviate poverty.

## **2.3 Theoretical Literature Review**

### **2.3.1 Theories of Poverty**

Numerous theoretical frameworks have been developed to understand the complex nature of poverty. These theories recognize that poverty is multidimensional and interconnected. The adoption of the Millennium Development Goals and later the Sustainable Development Goals reflects the acknowledgment that policies aimed at eradicating poverty must consider its multidimensional nature. These theories provide a theoretical backdrop for our study and guide us in examining the intricate interconnections between monetary and nonmonetary dimensions of poverty.

The concept of sustainable development is central to our study, underscoring the need to address multidimensional poverty for long-term well-being. Sustainable development goals emphasize the importance of addressing not only monetary poverty but also its interconnected dimensions (United Nations, 2017). This theory is crucial for comprehending the broader implications of energy poverty and its role in achieving sustainable development in Nigeria.

Sustainable Development Goal 1 (SDG 1 or Global Goal 1), one of the 17 Sustainable Development Goals established by the United Nations in 2015, calls for the end of poverty in all forms (United Nations, 2017). It aims to eradicate every form of extreme poverty, including the lack of food, clean drinking water, and sanitation. Achieving this goal includes finding solutions to new threats caused by climate change and conflict. SDG 1 focuses not just on people living in poverty but also on the services people rely on and social policy that either promotes or prevents poverty (United Nations, 2017).

The goal has seven targets and 13 indicators to measure progress. The five outcome targets are: eradication of extreme poverty; reduction of all poverty by half; implementation of social protection systems; ensuring equal rights to ownership, basic services, technology, and economic resources; and the building of resilience to environmental, economic, and social disasters. The two targets related to means of implementation SDG 1 are mobilization of resources to end poverty; and the establishment of poverty eradication policy frameworks at all levels (United Nations, 2017; Bartram, J., Brocklehurst, C., Bradley, D., Muller, M. and Evans, B. 2018).

Despite the ongoing progress, 10 percent of the world's population live in poverty and struggle to meet basic needs such as health, education, and access to water and sanitation (World Bank, 2020). Extreme poverty remains prevalent in low-income countries, particularly those affected by conflict and political upheaval (GSDRC, 2016). In 2015, more than half of the world's 736 million people living in extreme poverty lived in Sub-Saharan Africa (United Nations, 2020). The rural poverty rate stands at 17.2 percent and 5.3 percent in urban areas (in 2016) ( UNDESASD, 2016).

One of the key indicators that measure poverty is the proportion of the population living below the international and national poverty line. Measuring the proportion of the population covered by social protection systems and living in households with access to basic services is also an indication of the level of poverty (Ritchie et al., 2018). This understanding is essential for our study, which focuses on the relationship between estimated electricity bills and multidimensional poverty, as it aligns with the broader objectives of sustainable development (UNDP, 2016).

## **RESEARCH METHODOLOGY**

### **3.1 Research Design**

The research design chosen for this study is cross-sectional in nature. Cross-sectional research involves the collection of data from individuals or units at a specific point in time, allowing for the examination of a particular phenomenon within a defined population. This design suits our research objectives and the available resources, as it permits the study of energy poverty in Abakaliki, Ebonyi State, Nigeria, within a limited timeframe.

### **3.2 Area of the Study**

The selection of Abakaliki, Ebonyi State, Nigeria, as the study area is underpinned by its unique position as a prototypical urban center grappling with pronounced energy poverty challenges. Abakaliki, despite its urban classification, mirrors the prevalent issues experienced in many urban centers across Nigeria, contributing to the broader discourse on energy poverty. The sample size for this study is set at 150 residents.

In our calculation, a confidence level of 95% was chosen, corresponding to a Z-score of 1.96. The estimated proportion ( $P$ ) was based on preliminary data indicating the prevalence of energy poverty in the study area. The margin of error ( $E$ ) was set at 0.05.

### **3.3 Sources of Data**

Primary and secondary data was collected through the use of structured questionnaires administered to sampled households in Abakaliki, Ebonyi State, Nigeria. The questionnaire design aligns with established methodologies in energy economics and poverty measurement, ensuring that the data collected will be both comprehensive and specific to the challenges faced by households in the study area.

### **3.7 Data Analysis Techniques**

Data analysis in this study will employ a combination of descriptive and inferential statistical techniques to comprehensively examine the impact of estimated electricity bills on multidimensional poverty in Southeast Nigeria. The key techniques include:

### **3.8 Research Instruments**

Structured questionnaires stand as the principal instruments employed in this research, strategically crafted to elicit comprehensive data on estimated billings and their repercussions on various dimensions, including net profit for small businesses, disposable income for households, and the internally generated revenue of the Southeast States. The questionnaire's design aligns with the study's objectives, ensuring that the collected data addresses key variables pertinent to the research questions. The structured format provides a standardized approach, facilitating consistent data collection across diverse respondents. Moreover, the use of closed-ended questions aids in quantitative data analysis, allowing for a systematic and efficient examination of the specified research parameters.

### **3.9 Validity of the Research Instrument**

The face and content validity of the questionnaire is paramount to the accuracy and relevance of the collected data. To ensure this, the questionnaire was subjected to rigorous scrutiny by subject matter experts in the fields of electricity billing, business economics, and public finance. The reliability of the research instrument is upheld through a systematic pilot test

involving a small cohort of respondents. This preliminary assessment aims to evaluate the clarity, coherence, and appropriateness of the questionnaire's questions.

### 3.11 Model Specifications

The model specification for this study revolves around a regression analysis framework. Specifically, we will employ multiple linear regression models to examine the relationships between estimated billings and the identified variables, including net profit for small businesses, disposable income for households, and internally generated revenue for the Southeast States. The model formulation will consider the following general structure:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \epsilon$$

- Y represents the dependent variable (e.g., net profit, disposable income, or revenue),
- $\beta_0$  is the intercept term.,
- $\beta_1, \beta_2, \dots, \beta_n$  are the regression coefficients for the independent variables

$X_1, X_2, \dots, X_n,$

- $\epsilon$  denotes the error term.

The application of the model involves estimating the coefficients ( $\beta$ ) through statistical techniques, with SPSS serving as the analytical tool. This approach allows us to quantify the impact of estimated billings on each dependent variable, elucidating the nature and magnitude of these effects. Additionally, hypothesis testing will be conducted to ascertain the statistical significance of the relationships. The chosen model provides a systematic and rigorous means to explore the nuanced connections between estimated billings and the economic variables under investigation, contributing to a comprehensive understanding of their interplay.

## DATA PRESENTATION, ANALYSIS AND DISCUSSION

### 4.1 Data presentation

A total of 150 questionnaires were distributed for this survey, but only 100 were filled out correctly. 50 questionnaires were not appropriately filled out, so they can't be used for analysis.

**Table 1:** Demographic Information

CATEGORY	Option	Frequency	Percentage
Gender	Male	45	45%
	Female	55	55%
Age	18-24	18	18%
	25-34	27	27%
	35-44	25	25%
	45-54	17	17%
	55 and above	13	13%
Educational Level	Primary	20	20%
	Secondary School	45	45%
	Bachelor's Degree	20	20%
	Postgraduate Degree	15	15%

Occupation	Unemployed	12	12%
	Student	18	18%
	Skilled Worker	45	45%
	Professional/Managerial	25	25%

The demographic information presented in Table 1 above shows a diverse sample reflection of the population in Abakaliki, Ebonyi State, Nigeria. The gender distribution is relatively balanced, with 45% male and 55% female respondents. Age-wise, the majority falls within the productive working-age range of 25-34 (27%) and 35-44 (25%), highlighting the relevance of our research to individuals actively engaged in economic activities. Educational levels show a well-distributed representation, with 20% having attained a Bachelor's Degree, emphasizing the importance of the study among individuals with varying educational backgrounds.

Occupationally, the sample reflects the economic diversity of the region. The presence of unemployed respondents (12%) underscores the potential vulnerability of certain segments of the population to energy poverty. Students (18%) constitute a significant demographic, offering insights into the impact of estimated billings on the disposable income of households. Skilled workers (45%) and professionals/managers (25%) represent key contributors to economic activities, making their perspectives crucial in assessing the effects on net profit for small businesses and the internally generated revenue of South East States. This comprehensive demographic profile ensures a well-rounded exploration of the multidimensional impacts of estimated billings in our study area.

## 4.2 Descriptive analysis

**TABLE 2: EFFECTS ON NET PROFIT OF SMALL BUSINESSES**

S/N	QUESTIONS	SA	A	N	D	SD	Mean	Std. Dev.
1	Estimated billings significantly reduces the net profit of your business.	15	25	40	15	5	3.3000	1.05887
2	The current system of estimated billings positively impacts the financial performance of small businesses in the South East.	5	10	25	40	20	2.4000	1.07309
3	Small businesses face challenges in accurately budgeting for electricity costs due to estimated billings.	25	35	20	15	5	3.6000	1.16342
4	The uncertainty of estimated billings affected your ability to plan and manage the financial aspects of your business.	20	30	30	15	5	3.4500	1.12254
5	You are satisfied with the current arrangement of estimated billings and its impact on the net profit of small businesses in the South East.	5	10	20	35	30	2.2500	1.14040

The analysis of responses from small businesses (Table 1) in Abakaliki indicates a prevalent dissatisfaction with the current system of estimated billings. A significant portion of respondents (40%) perceive estimated billings as significantly reducing their net profit, while

60% agree that small businesses face challenges in accurately budgeting for electricity costs due to estimated billings. Additionally, 60% of respondents believe that the uncertainty of estimated billings affects their ability to plan and manage the financial aspects of their businesses. Contrary to the notion that the current system positively impacts financial performance, a majority (40%) disagrees or strongly disagrees. Overall, the findings reveal a negative sentiment among small businesses towards the current arrangement of estimated billings and its impact on net profit in Abakaliki.

**TABLE 3: EFFECTS ON HOUSEHOLDS**

S/N	QUESTIONS	SA	A	N	D	SD	Mean	Std. Dev.
6	Estimated billing impact the income of households.	20	30	30	15	5	3.4500	1.12254
7	Estimated billings contribute to financial challenges for households in managing their income.	25	35	25	10	5	3.6500	1.11351
8	Is it challenging to meet other essential needs due to the financial burden of estimated electricity bills?	30	30	25	10	5	3.7000	1.15032
9	The uncertainty of estimated billings has affected the financial stability of your households.	25	30	30	10	5	3.6000	1.11916
10	Current arrangement of estimated billings and its impact on the income of households in the South East is not satisfactory.	25	35	25	10	5	3.6500	1.11351

The data presented in Table 3 elucidates a discernible strain that estimated billings impose on households within the region. A noteworthy 65% of respondents believe that estimated billings significantly affect household income, leading to financial challenges in managing their resources. Furthermore, an overwhelming 70% of participants find it challenging to meet other essential needs due to the financial burden imposed by these estimated electricity bills. This sentiment is further substantiated by 60% of respondents who feel that the uncertainty surrounding estimated billings has compromised the financial stability of their households. In summation, the prevailing sentiment among households indicates dissatisfaction with the existing arrangement of estimated billings, highlighting its adverse effects on disposable income and overall financial stability.

### 4.3 Test of Hypotheses

**TABLE 5: REGRESSION ANALYSIS TO TEST H1**

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.146	0.032		-4.630	0.010
	Estimated Electricity Billings	-0.994	0.009	0.996	105.111	0.010

a. Dependent Variable: Netprofit

The regression analysis results (Table 5) indicate a highly significant and positive impact of Estimated Electricity Billings on Net Profit for small businesses in Southeast Nigeria. The coefficient for Estimated Electricity Billings is -0.994, with a standard error of 0.009 and a t-value of 105.111. The p-value is 0.010, confirming the statistical significance of the relationship.

Considering hypothesis H1, which asserts "There is no significant effect of estimated billing on the net profit of small businesses in Southeast Nigeria," the results prompt the rejection of this hypothesis. The low p-value of 0.010 signifies that estimated billing has a significant effect on the net profit of small businesses. The negative coefficient (-0.994) further indicates that an increase in estimated electricity billings corresponds to a decrease in net profit for small businesses. Therefore, based on the regression analysis, we conclude that estimated billing significantly affects the net profit of small businesses in Southeast Nigeria.

**TABLE 6: REGRESSION ANALYSIS TO TEST H2**

<b>Coefficients</b>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.420	0.078		5.395	0.000
	EstimatedElectricityBillings	-1.007	0.023	0.975	43.222	0.00

a. Dependent Variable: DisposalIncome

The results (Table 6) of the regression analysis provide significant insights into the impact of Estimated Electricity Billings on the disposable income of households in the South East states. The coefficient for Estimated Electricity Billings is -1.007, with a standard error of 0.023 and a t-value of 43.222. The p-value associated with this coefficient is 0.000, indicating a statistically significant relationship.

Concerning hypothesis H2, which posits "Estimated billing does not significantly impact the disposable income of households in the South East states," the evidence from the regression analysis contradicts this hypothesis. The low p-value of 0.000 suggests that estimated billing has a significant impact on the disposable income of households. The negative coefficient (-1.007) indicates that an increase in estimated electricity billings corresponds to a decrease in disposable income for households. Therefore, based on the regression analysis, we reject hypothesis H2 and assert that estimated billing significantly impacts the disposable income of households in the South East states.

**TABLE 7: REGRESSION ANALYSIS TO TEST H3**

<b>Coefficients</b>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.274	0.056		-4.895	0.001
	Estimated Electricity Billings	0.999	0.017	0.987	59.668	0.010

a. Dependent Variable: Internally Generated Revenue

The results of the regression analysis (Table 7) examining the impact of Estimated Electricity Billings on the Internally Generated Revenue (IGR) of South East States reveal important insights. The coefficient for Estimated Electricity Billings is 0.999, with a standard error of 0.017 and a t-value of 59.668. The p-value associated with this coefficient is 0.000, indicating a statistically significant relationship.

Addressing hypothesis H3, which posits "There is no significant impact of estimated electricity bills on the Internally Generated Revenue (IGR) of South East States," the evidence from the regression analysis contradicts this hypothesis. The very low p-value of 0.000 suggests that estimated electricity bills have a significant impact on the IGR of South East States. The positive coefficient (0.999) implies that an increase in estimated electricity billings corresponds to an increase in the Internally Generated Revenue of the states.

Therefore, based on the regression analysis, we reject hypothesis H3 and assert that estimated electricity bills significantly impact the Internally Generated Revenue (IGR) of South East States.

#### **4.4 Discussion of findings**

A comprehensive analysis of the data collected from the survey conducted in Abakaliki, Ebonyi State, Nigeria. Out of the 150 distributed questionnaires, 100 were correctly filled out and considered for analysis, providing a robust foundation for our investigation into the impacts of estimated electricity billings on small businesses, households, and the Internally Generated Revenue (IGR) of South East States.

The demographic information presented in Table 1 reflects the diversity of our sample, ensuring a comprehensive exploration of the multidimensional impacts of estimated billings in the study area. With a balanced gender distribution, a majority of respondents falling within the productive working-age range, and varied educational and occupational backgrounds, our study captures the perspectives of individuals across different segments of the population.

The descriptive analysis in Tables 2, 3, and 4 sheds light on the sentiments and experiences of small businesses, households, and the broader economic landscape regarding estimated electricity billings. For small businesses, the findings reveal a prevalent dissatisfaction with the current system, with a significant proportion perceiving negative impacts on net profit and financial planning. Similarly, households express challenges in managing their income and meeting essential needs due to the financial burden of estimated electricity bills.

The regression analysis, presented in Tables 5, 6, and 7, further delves into the statistical relationships and tests the hypotheses formulated in Chapter Three. The results provide crucial insights into the significant impact of estimated electricity billings on the net profit of small businesses, the disposable income of households, and the Internally Generated Revenue (IGR) of South East States. The rejection of hypotheses H1, H2, and H3 underscores the necessity for policy interventions and strategic measures to address the adverse effects of estimated billings on various facets of the economy.

In conclusion, our findings contribute to the growing body of knowledge on energy poverty and highlight the urgent need for tailored interventions to mitigate the negative consequences of estimated electricity billings. The diverse perspectives gathered from small businesses, households, and the economic landscape offer a nuanced understanding of the challenges faced by the population in Abakaliki. This chapter sets the stage for the subsequent sections, providing a solid foundation for policy recommendations and future research directions.

## **SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS**

### **5.1 Summary of Findings**

The research endeavors to comprehensively understand the multifaceted impacts of estimated electricity billings on small businesses, households, and the Internally Generated Revenue (IGR) of South East States in Abakaliki, Ebonyi State, Nigeria. The findings from the data analysis reveal significant insights into the diverse perspectives of the population.

In the demographic analysis, a well-rounded representation of the population was observed, ensuring a comprehensive exploration of the study's multidimensional impacts. The balanced gender distribution, the majority falling within the productive working-age range, and varied educational and occupational backgrounds provide a holistic understanding of the challenges posed by estimated billings.

The descriptive analysis highlights dissatisfaction among small businesses with the current system of estimated billings, indicating adverse effects on net profit and financial planning. Households, too, face challenges in managing their income and meeting essential needs due to the financial burden of estimated electricity bills. The nuanced perspectives in Table 4 further underscore the complexities associated with the impact of estimated billings on the Internally Generated Revenue (IGR) of South East States.

The regression analysis, detailed in Tables 5, 6, and 7, confirms the statistical significance of the relationships tested. The rejection of hypotheses H1, H2, and H3 suggests that estimated electricity billings significantly impact the net profit of small businesses, the disposable income of households, and the IGR of South East States. The negative coefficients in H1 and H2 indicate adverse effects, while the positive coefficient in H3 signifies an increase in IGR with rising estimated electricity billings.

### **5.2 Conclusion**

In conclusion, the research provides a comprehensive understanding of the adverse impacts of estimated electricity billings in Abakaliki. The dissatisfaction expressed by small businesses and households, coupled with the significant statistical relationships identified, emphasizes the urgent need for policy interventions. The findings underscore the far-reaching consequences of estimated billings on economic entities and the broader economic landscape.

### **5.3 Recommendations**

The findings of this study offer valuable insights into the challenges posed by estimated electricity billings in Abakaliki, Ebonyi State, Nigeria. In light of these findings, several recommendations are put forth to address the identified issues and foster a more sustainable and equitable energy framework.

To begin with, a comprehensive review and reform of the existing billing system are paramount. Such an initiative should aim at enhancing transparency, accuracy, and fairness in the estimation process. This entails a close examination of the methodologies employed in estimating bills, ensuring that they align with the actual consumption patterns of consumers. Policymakers and relevant authorities should collaborate to implement reforms that address the concerns raised by both small businesses and households.

Moreover, targeted policy interventions are recommended to alleviate the adverse impacts of estimated billings on small businesses and households. These measures should be tailored to the unique challenges faced by each group, taking into account their differing economic

dynamics. Financial support programs for those vulnerable to the financial burdens imposed by estimated electricity bills can provide a safety net for affected individuals and businesses.

In line with the promotion of consumer empowerment, encouraging the adoption of prepaid meters emerges as a key recommendation. Individuals and businesses should be incentivized to transition to prepaid meters due to the inherent benefits they offer. Prepaid meters, with their pay-as-you-use flexibility, not only provide consumers with greater control over their energy consumption but also contribute to more accurate billing and improved financial management.

Furthermore, efforts should be directed towards enhancing energy efficiency measures. This involves educating consumers about energy-saving practices and technologies, fostering a culture of responsible energy use. By optimizing energy efficiency, both at the individual and business levels, the overall demand for electricity can be managed more effectively, reducing the financial burden on consumers.

The positive impact of estimated billings on the Internally Generated Revenue (IGR) of South East States suggests an opportunity for strategic revenue generation. Policymakers should explore ways to leverage this impact for the benefit of the states, ensuring that revenue is equitably distributed and reinvested in critical sectors to foster sustainable economic development.

Lastly, public awareness campaigns play a pivotal role in disseminating information about the benefits of prepaid meters. By educating residents, businesses, and policymakers, these campaigns contribute to building a collective understanding of the advantages of pay-as-you-use systems and their positive impact on financial planning.

In conclusion, the implementation of these recommendations requires collaborative efforts from policymakers, energy authorities, and the community. Addressing the challenges posed by estimated electricity billings necessitates a multifaceted approach that prioritizes fairness, accuracy, and consumer empowerment within the energy sector.

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ERIN 2ND E-PROCEEDING

# Acceptability of Off-Grid Renewable Energy and Viable Business Models for Rural Electrification in North-Central Nigeria

**Solomon Terkaa Myem<sup>1</sup> & Dr. Marshin Amenger<sup>2</sup>**

Department of Industrial Technology, Moses Orshio Adasu University Makurdi, Benue State.  
Corresponding Author's Email: solomonmyem@gmail.com

## ABSTRACT

*This study examined the acceptability of off-grid renewable energy systems and the viability of business models for rural electrification in North-Central Nigeria. A descriptive research design was adopted, covering selected states and relevant institutions. The study population comprised 1,150 respondents, from which a sample of 291 participants—including lecturers, entrepreneurs, ministry personnel, and community leaders—was selected. Data were collected using a structured questionnaire and analyzed using descriptive statistics and the Kruskal–Wallis H test at a 0.05 level of significance, with Dunn–Bonferroni post hoc analysis applied where necessary. Findings revealed a moderate to high level of acceptability of off-grid power solutions across all stakeholder groups, with community members showing slightly higher acceptance. The Kruskal–Wallis test indicated no statistically significant difference in perceptions of acceptability among respondents, suggesting a shared consensus. The study also found strong agreement on the viability of business models such as Pay-As-You-Go, mini-grids, Energy-as-a-Service, and public-private partnerships. However, a statistically significant difference was observed in perceptions of these models, with lecturers expressing stronger agreement than Ministry personnel. The study concludes that off-grid renewable energy systems are widely accepted and represent a viable solution for rural electrification. Based on the findings, it is recommended that stakeholders leverage the high level of community acceptance by actively involving local communities in the planning, implementation, and management of off-grid projects to enhance sustainability. Additionally, efforts should be made to strengthen alignment between policy actors and other stakeholders by addressing institutional concerns through improved regulatory clarity, stakeholder engagement, and capacity-building to increase confidence in the viability of off-grid business models.*

**KEYWORDS:** Acceptability, Off-Grid, Renewable Energy, Viable Business Models, Rural Electrification, and North-Central Nigeria

## Introduction

Access to reliable and affordable electricity is widely acknowledged as a critical driver of economic development, improved living standards, and poverty reduction. However, a significant proportion of the population in developing countries, particularly in rural and remote areas, still lacks access to electricity. In Nigeria, there is a persistent disparity between urban and rural electrification levels, with rural communities being disproportionately underserved (Aliyu et al., 2015). Reports indicate that a substantial segment of the rural population lacks stable electricity supply, thereby limiting economic opportunities and social development.

The inadequacy of electricity access in Nigeria is largely linked to the limitations of the centralized national grid. The grid is characterized by inefficiencies such as poor maintenance, overloading, and high transmission losses (Salihu et al., 2020). Furthermore, extending grid infrastructure to remote areas is often economically and technically impractical due to high capital costs and geographical challenges. Consequently, rural communities remain largely excluded from reliable electricity, while even urban areas experience frequent power outages (Audu & Adamu, 2022). These challenges highlight the need for alternative approaches to energy provision.

In response, the Federal Government established the Rural Electrification Agency (REA) to expand electricity access across the country. The agency aims to bridge the electrification gap and promote socio-economic development. Despite these efforts, progress has been limited, indicating persistent structural and policy-related challenges in the energy sector. Additionally, rapid population growth has further increased the demand for reliable and sustainable energy systems, making it imperative to explore innovative solutions (Samuel et al., 2022).

Off-grid electrification has emerged as a viable alternative to conventional grid extension, particularly in remote and underserved areas. Off-grid systems are decentralized energy solutions that operate independently of the national grid, allowing localized generation and distribution of electricity (Tania & Anisuzzaman, 2016). These systems offer several advantages, including reduced transmission losses, flexibility, and scalability to meet growing energy demands. They also support environmental sustainability by promoting the use of renewable energy sources and reducing reliance on fossil fuels.

Several off-grid technologies are suitable for rural electrification, depending on local resource availability. Solar photovoltaic (PV) systems are widely adopted due to their reliability and the abundance of solar resources in Nigeria (Sunday et al., 2023). Small hydropower systems are effective in areas with sufficient water resources, while wind energy systems have limited applicability in inland regions. Biomass gasification systems also provide an alternative by converting agricultural residues into energy, although sustainability considerations must be addressed. A key advantage of these technologies is their modular and scalable nature, which allows gradual expansion as energy demand increases (Salihu et al., 2020).

Despite their technical potential, the success of off-grid systems depends largely on community acceptance and participation. Acceptance is influenced by factors such as perceived socio-economic benefits, affordability, reliability, and cultural compatibility. Communities are more likely to adopt off-grid solutions when they experience improvements in living conditions, including better education, increased income-generating opportunities, and enhanced quality of life (Babalola et al., 2022). However, long-term acceptance requires consistent system performance and reliability. Technical performance is a crucial determinant of user satisfaction. Systems that frequently fail or require complex maintenance often lead to dissatisfaction, particularly in rural areas where technical expertise is limited. Therefore, off-grid systems must be designed to be simple, reliable, and easy to maintain locally. Technologies that align with local technical capacities are more likely to achieve sustained adoption.

Affordability is another key factor influencing adoption. While initial installation costs may be subsidized, ongoing maintenance and replacement costs can pose financial challenges for low-income households. Addressing this issue requires innovative financing mechanisms and sustainable business models. Integrating energy systems with local economic activities can further enhance financial viability by generating income that supports system operation and maintenance. Community engagement is essential for ensuring the success and sustainability of off-grid electrification projects. Involving community members in planning, design, and

implementation fosters a sense of ownership and trust (Agoundemba et al., 2023). Participatory approaches also ensure that energy solutions are tailored to local needs and socio-cultural contexts, thereby improving their acceptance. In addition, awareness campaigns and training programs can help overcome skepticism and promote understanding of off-grid technologies

The broader economic and policy environment also plays a significant role in shaping the adoption of off-grid systems. Factors such as affordability, reliability, and social influence have been identified as key determinants of user acceptance (Bhattacharyya, 2018). Supportive government policies, including subsidies and incentives for renewable energy investments, are essential for promoting adoption. Conversely, weak regulatory frameworks and inadequate institutional support can hinder implementation

### **Aims and objective of the study**

1. The acceptability of off-grid renewable energy power communities in North-central Nigeria.
2. The most viable business models for implementing off-grid electrification projects in rural communities of North-Central Nigeria

### **Research Questions**

1. To what extent will off-grid renewable energy power be acceptable in rural communities in North-central Nigeria?
2. What are the most viable business models for implementing off-grid electrification projects in rural communities of North-Central Nigeria?

### **Research Hypotheses**

**Ho<sub>1</sub>** There is no statistically significant difference between the mean responses of Ministry Personnel, Entrepreneurs, and Community Members on acceptable off-grid renewable energy power in rural communities.

**Ho<sub>2</sub>** There will be no significant differences among entrepreneurs in the renewable energy sector, and community leaders on the preferred business models for implementing off-grid electrification projects in rural communities of North-Central Nigeria.

### **Methodology**

This study adopted a descriptive research design. The research was conducted in North-Central Nigeria, specifically covering Benue, Kogi, Nasarawa, and Niger States, as well as the Federal Ministry of Power in Abuja. The population of the study comprised 1,150 respondents, from which a sample size of 291 was determined using the Morgan table. The sample included engineering and technology lecturers specializing in electrical power systems, renewable energy entrepreneurs, personnel from the Ministry of Power and related agencies, and community leaders. Data were collected using a researcher-designed instrument titled Off-Grid Renewable Energy Power Supply Questionnaire (OGRPSQ), which contained 177 items.

The collected data were analyzed using descriptive statistics, including frequency counts, percentages, means, and standard deviations. For hypothesis testing, the Kruskal–Wallis H test was employed at a 0.05 level of significance to determine differences among respondent groups. Where significant differences were identified, Dunn’s post-hoc pairwise comparison

test with Bonferroni correction was applied. Interpretation of responses was guided by the real limits of the Likert scale.

## Result and discussion

**Research Question one:** To what extent will off-grid power solutions be acceptable in rural communities in North-central Nigeria?

Table 1: **Mean and Standard Deviation of Respondents' Perceptions on Community Acceptability of Off-Grid Power Solutions ( $n_1 = 180$ ,  $n_2 = 142$ ,  $n_3 = 42$ )**

S/N	Statements	M <sub>1</sub>	SD <sub>1</sub>	M <sub>2</sub>	SD <sub>2</sub>	M <sub>3</sub>	SD <sub>3</sub>
1	Accept adoption of alternative electricity solutions	2.88	1.09	2.81	1.11	2.98	1.14
2	Support community-wide solar or hybrid systems	2.98	1.09	2.94	1.06	3.05	1.22
3	Trust organisations promoting renewable energy	3.25	0.96	3.22	0.93	3.18	1.01
4	Willing to participate in community-owned projects	3.33	2.44	3.19	0.99	3.03	1.03
5	Value involvement of community leaders	3.21	0.98	3.14	1.01	3.18	1.06
6	Willing to attend awareness programmes	3.02	1.06	3.13	1.06	2.88	1.20
7	Consider off-grid energy viable long-term	2.89	1.09	3.07	1.10	2.63	1.10
8	Alignment with cultural and religious values	3.03	1.06	3.16	1.11	2.90	1.10
9	Support discussing energy in community meetings	3.23	1.11	3.33	1.13	3.35	1.21
10	Encouraged by past energy projects	3.25	1.07	3.18	1.09	3.18	1.20
11	Community can operate and maintain systems	3.20	1.02	3.10	1.08	3.03	1.14
12	Trust in managing shared infrastructure	3.39	0.94	3.36	0.90	3.38	1.00
13	Willing to encourage others	3.68	0.84	3.19	1.03	3.33	1.12
14	Elders support clean energy	3.28	1.05	3.16	1.11	3.18	1.15
15	Support training initiatives	3.24	1.02	3.27	0.98	3.23	1.12
16	Support replacing petrol generators	3.14	0.99	3.04	1.00	3.30	0.91
17	Support youth training programmes	3.10	0.98	2.99	0.96	3.20	0.94
18	Cultural and religious alignment	3.18	0.95	3.15	1.01	3.03	0.86
19	Open to private sector partnerships	3.26	0.95	3.22	1.03	2.98	0.83
20	Accept decentralised community-managed systems	3.16	1.01	3.09	1.06	2.93	1.02
21	Confidence in sustaining off-grid systems	3.19	0.93	3.05	1.04	3.00 (0.85)	0.85
	<b>Overall Mean &amp; SD</b>	<b>3.17</b>	<b>1.20</b>	<b>3.11</b>	<b>1.04</b>	<b>3.06</b>	<b>1.07</b>

**Key:**  $n_1$  = community,  $n_2$  = entrepreneurs,  $n_3$  = ministry,  $M_1$  = mean of community,  $M_2$  = mean of entrepreneurs,  $M_3$  = mean of ministry,  $SD_1$  = standard deviation of community,  $SD_2$  = standard deviation of entrepreneurs,  $SD_3$  = standard deviation of ministry of personnel

The results presented in Table 5 and Figure 5 indicate generally positive perceptions of community acceptability of off-grid power solutions across the three respondent groups. The overall mean scores, shown in the final row of Table 5, reveal that community members reported the highest level of agreement ( $M = 3.17$ ,  $SD = 1.20$ ), followed closely by entrepreneurs ( $M = 3.11$ ,  $SD = 1.04$ ) and Ministry personnel ( $M = 3.06$ ,  $SD = 1.07$ ). These mean values, all exceeding the scale midpoint of (lower limit = 2.61, upper limit = 3.40), suggest a moderate to high level of support for off-grid power projects, including willingness to participate in community-owned projects, support for training and awareness programmes, and confidence in the community's ability to sustain decentralised energy systems. The relatively comparable SD across the three groups indicate a similar spread of responses, implying shared perceptions among stakeholders despite differences in professional roles.

**Research Question one:** What are the most viable business models for implementing off-grid electrification projects in rural communities of North-Central Nigeria?

**Mean and Standard Deviation of Respondents' Perceptions of Viable Business Models for Off-Grid Electrification in Rural Communities** ( $n_1 = 87$ ;  $n_2 = 142$ ,  $n_3 = 42$ )

S/N	Statements	$M_1$	$SD_1$	$M_2$	$SD_2$	$M_3$	$SD_3$
1	PAYG model is viable	4.14	0.81	4.22	0.81	3.95	0.39
2	EaaS improves affordability	4.20	0.83	4.22	1.01	4.08	0.53
3	Mini-grid model is sustainable	4.17	0.82	3.95	1.24	4.00	1.11
4	Community-owned models promote sustainability	4.14	0.89	4.18	0.95	3.68	1.21
5	Private sector involvement is essential	4.02	0.91	4.19	0.73	4.03	2.18
6	PPP model is effective	4.05	0.93	3.94	0.98	3.65	1.05
7	Subsidy-based models improve access	4.09	0.88	4.01	1.08	4.13	0.79
8	Donor-funded models are reliable initially	4.17	0.94	4.17	1.12	3.53	1.30
9	Flexible payment options increase adoption	4.13	0.99	4.25	3.66	3.68	1.27
10	Local entrepreneurship is critical	4.16	0.97	3.72	1.30	3.45	1.26
11	Government + private investment improves outcomes	4.76	0.87	4.17	0.96	4.13	0.85
12	Regular maintenance ensures sustainability	4.17	0.87	4.26	0.87	3.75	1.32
13	Financing options encourage adoption	4.21	0.94	4.08	1.12	4.45	0.75
14	Community-private partnerships improve performance	4.22	0.87	4.24	0.89	3.93	1.27
15	End-user involvement improves success	4.21	0.86	4.15	1.04	3.85	1.29
16	Transparent billing increases willingness to pay	4.25	0.70	4.09	0.99	4.58	0.50
17	Affordable tariffs enhance sustainability	4.71	0.83	4.29	0.70	4.13	0.33
18	Limited technical expertise constrains success	4.20	0.88	4.19	0.95	3.33	1.67

19	Income-generating energy use improves viability	4.18	0.83	4.32	0.76	4.68	0.73
20	Overall satisfaction with current business models	4.24	0.76	4.44	0.50	3.83	1.34
<b>Overall Mean and SD</b>		<b>4.21</b>	<b>0.90</b>	<b>4.17</b>	<b>1.04</b>	<b>4.01</b>	<b>1.11</b>

**Key:**  $n_1$  = lecturers,  $n_2$  = entrepreneurs,  $n_3$  = ministry,  $M_1$  = mean of lecturers,  $M_2$  = mean of entrepreneurs,  $M_3$  = mean of ministry,  $SD_1$  = standard deviation of lecturers,  $SD_2$  = standard deviation of entrepreneurs,  $SD_3$  = standard deviation of ministry personnel.

The results presented in Table 7 shows a strong agreement among respondents regarding the viability of various business models for implementing off-grid electrification in rural communities. As shown in the overall mean row in Table 7, lecturers reported the highest level of agreement ( $M = 4.21$ ,  $SD = 0.90$ ), followed closely by entrepreneurs ( $M = 4.17$ ,  $SD = 1.04$ ) and Ministry personnel ( $M = 4.01$ ,  $SD = 1.11$ ). These mean scores, all well above the midpoint of the scale, suggest a broadly positive perception of existing and emerging off-grid business models. High ratings across key items indicate strong support for Pay-As-You-Go, mini-grid, Energy-as-a-Service, and community-owned models, particularly when combined with private sector participation, public-private partnerships, flexible payment mechanisms, and access to financing.

### Hypothesis one

There is no statistically significant difference between the mean responses of Ministry Personnel, Entrepreneurs, and Community Members on acceptable off-grid renewable energy power in rural communities.

### Kruskal-Wallis Test Comparing Perceptions of Off-Grid Technologies Acceptability Across Respondent Groups

<b>Group</b>	<b>n</b>	<b>Mean Rank</b>	<b><math>\chi^2 (2)</math></b>	<b>P.value</b>	<b>Effect Size (<math>\eta^2_h</math>)</b>
Community	180	80.25	3.61	0.164	0.009
Ministry	42	85.33			
Entrepreneurs	142	91.69			
<b>Total</b>	<b>364</b>				

**Note:**  $\eta^2_h$  (eta-squared for Kruskal-Wallis) was calculated using  $\eta^2_h = (H - k + 1)/(N - k)$ , where  $H = 3.612$ ,  $k = 3$  groups, and  $N = 364$ .

The results indicated in Table 3 that there was no statistically significant difference between the groups,  $\chi^2(2) = 3.61$ ,  $p = 0.164$ . Although entrepreneurs had a higher mean rank (91.69) compared to Ministry Personnel (85.33) and community members (80.25). These differences were not statistically significant. The calculated effect size was very small ( $\eta^2_h = 0.009$ ), suggesting that respondent category accounted for less than 1% of the variance in perceived acceptability of off-grid technologies. Therefore, the null hypothesis was retained, indicating that perceptions of off-grid technologies acceptability do not significantly differ across respondent groups.

## Hypothesis Two:

There will be no significant differences among entrepreneurs in the renewable energy sector, and community leaders on the preferred business models for implementing off-grid electrification projects in rural communities of North-Central Nigeria.

Table 2: **Kruskal-Wallis Test Comparing Perceptions of Viable Business Models Across Respondent Groups**

<i>Group</i>	<i>n</i>	<i>Mean Rank</i>	$\chi^2 (2)$	<i>P.value</i>	<i>Effect Size (<math>\eta^2_h</math>)</i>
<b>Lecturers</b>	<b>85</b>	<b>146.10</b>	<b>9.974</b>	0.007	0.030
Ministry	42	<b>100.26</b>			
Entrepreneurs	142	<b>135.18</b>			
<b>Total</b>	<b>269</b>				

**Note:**  $\eta^2_h$  (eta-squared for Kruskal-Wallis) was calculated using  $\eta^2_h = (H - k + 1) / (N - k)$ , where  $H = 9.974$ ,  $k = 3$  groups, and  $N = 269$ .

A Kruskal-Wallis H test was conducted to determine whether there were statistically significant differences in perceptions of viable business models for off-grid electrification among lecturers, Ministry personnel, and entrepreneurs. The results as shown in Table 2 revealed a statistically significant difference between groups,  $\chi^2(2) = 9.97$ ,  $p = 0.007$ . Lecturers had the highest mean rank (146.10), followed by entrepreneurs (135.18), while Ministry personnel recorded the lowest mean rank (100.26). The effect size was small ( $\eta^2_h = 0.030$ ), indicating that respondent category accounted for approximately 3% of the variance in perceptions of viable business models. Given the significant result, the null hypothesis was rejected. This suggests that perceptions of viable business models for off-grid electrification differ significantly across respondent groups.

Since the Kruskal-Wallis test was statistically significant,  $\chi^2(2) = 9.97$ ,  $p = 0.007$ , a pairwise comparison were performed using the **Dunn procedure with Bonferroni correction** to control for Type I error across three comparisons ( $\alpha$  adjusted =  $0.05/3 = 0.017$ ) as presented in Table 4: **Post Hoc Pairwise Comparisons for Viable Business Model**

<b>Comparison</b>	<b>Mean Rank Difference</b>	<b>Adjusted p-value</b>	<b>Interpretation</b>
Lecturer vs Ministry	45.84	0.006	Significant
Lecturer vs Entrepreneurs	10.92	0.284	Not Significant
Entrepreneurs vs Ministry	34.92	0.021	Not Significant (after Bonferroni adjustment)

*Bonferroni-adjusted significance level = 0.017.*

Following a significant Kruskal-Wallis test, Dunn-Bonferroni post hoc analysis (adjusted  $\alpha = 0.017$ ) revealed that **only lecturers and Ministry personnel differed significantly**, with lecturers showing higher perceptions of viable business models ( $p = 0.006$ ). No significant

differences were found between lecturers and entrepreneurs or between entrepreneurs and Ministry personnel after adjustment. Overall, the observed group difference was mainly driven by the gap between lecturers and Ministry personnel, while entrepreneurs' views were not significantly different from either group.

### **Findings of the study**

Respondents generally showed moderate to high acceptance of off-grid power solutions, with community members expressing slightly stronger support. All stakeholder groups demonstrated willingness to adopt decentralized systems, supported by confidence in community participation, training, and public–private partnerships.

on the viability of various business models, including Pay-As-You-Go, mini-grids, Energy-as-a-Service, and public–private partnerships. Flexible payment systems, affordability, and blended financing were identified as critical for sustainability, alongside collaboration between government and private sector actors.

Although a statistically significant difference existed in perceptions of business model viability, lecturers expressed stronger agreement than Ministry personnel. However, the small effect size indicates that the practical difference across groups is limited.

Findings further revealed broad consensus across stakeholders on the acceptability of off-grid solutions, as no significant differences were observed. This suggests that social acceptance is not a major barrier to implementation, aligning with existing studies that highlight positive attitudes toward decentralized energy systems. However, challenges such as affordability, technical capacity, and governance remain critical.

Finally, while overall support for off-grid business models is strong, institutional actors appear more cautious compared to academics. This may be due to concerns about policy, regulation, and implementation risks. The implication is that improving regulatory clarity, strengthening institutional capacity, and promoting collaboration between public and private sectors are essential for successful deployment.

### **Discussion of Findings**

The study found moderate-to-high acceptability of off-grid electricity solutions across community members, entrepreneurs, and Ministry personnel. Community members expressed the strongest support, followed closely by entrepreneurs and Ministry personnel, suggesting broad stakeholder endorsement of decentralized electrification. Statistical analysis revealed no significant differences in perceptions of acceptability across these groups, indicating a shared consensus. This finding aligns with diffusion of innovation theory, which posits that widespread perceived benefits and compatibility reduce subgroup resistance to new technologies. It also corroborates previous studies, such as Haliru and Ahmed (2022), who reported favorable attitudes toward solar home systems among rural households, and Joseph et al. (2019), who observed that rural users adopt electricity for productive and domestic purposes despite systemic constraints. These results suggest that social acceptability is not a primary barrier, although practical implementation must still address affordability, technical capacity, and governance to ensure successful deployment.

Regarding off-grid business models, respondents across all groups showed strong agreement on the viability of Pay-As-You-Go (PAYG), Energy-as-a-Service (EaaS), mini-grids, community-owned models, public–private partnerships (PPPs), and flexible payment mechanisms. However, significant differences emerged in perceptions between stakeholder groups: lecturers reported higher agreement with the feasibility of these models than Ministry

personnel, while entrepreneurs' views did not significantly differ from either group after Bonferroni adjustment. This suggests that institutional actors may be more cautious or skeptical about business model feasibility, potentially due to regulatory, fiscal, or operational concerns. These findings are consistent with Haliru and Ahmed (2022), who emphasized the importance of innovative pricing models to bridge affordability gaps, and Meyer et al. (2021), who highlighted the need for enabling policy frameworks to facilitate collaboration between private enterprises and public institutions.

Overall, the findings indicate broad support for off-grid solutions and their business models, but also highlight the importance of strengthening institutional confidence. Clear regulatory guidance, risk-sharing mechanisms, and capacity-building initiatives are critical to aligning policy actors with implementation stakeholders. Addressing these factors is essential to ensure that off-grid electrification initiatives are both socially accepted and operationally sustainable, thereby contributing to rural development and enhanced energy access in underserved communities.

### **Conclusion and Recommendations**

The study found that off-grid electricity solutions are broadly accepted across key stakeholders, including community members, entrepreneurs, and Ministry personnel, with community members expressing the highest level of support. While lecturers reported slightly stronger confidence in the viability of off-grid business models than Ministry personnel, overall agreement existed regarding models such as Pay-As-You-Go, mini-grids, Energy-as-a-Service, and public-private partnerships. These findings indicate that social acceptance is not a major barrier to implementation. However, successful deployment requires addressing challenges related to affordability, technical capacity, governance, and institutional confidence, ensuring that off-grid systems are both socially and operationally sustainable.

Based on these findings, several recommendations are proposed. Policymakers should provide clear regulatory frameworks and supportive policies to reduce institutional skepticism and enhance confidence in business model viability. Flexible financing mechanisms, including Pay-As-You-Go and blended subsidy models, should be implemented to improve affordability for rural households. Technical training and participatory approaches should empower local communities to manage and maintain systems effectively, fostering ownership and sustainability. Additionally, fostering collaboration between government, private sector, and community stakeholders will help align policy, implementation, and operational objectives, ensuring the successful scaling of off-grid electrification initiatives.

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# Comparative Analysis of Nasal Carriage Antibiotic Resistance *Staphylococcus aureus* Isolated from Hospitalized and Non-Hospitalized Patients Within Urua Akpan Community

Aniebiet M. Essien<sup>1</sup>, Itoro U. Okon<sup>2</sup>, Hudson H. Oronubong<sup>3</sup> & Umoh, Rachel E.<sup>4</sup>

Department of Biological Sciences, School of Applied Sciences, Akwa Ibom State, Polytechnic, Ikot Osurua, Ikot Ekpene, Akwa Ibom State, Nigeria

Emails: [aniebietessien20@gmail.com](mailto:aniebietessien20@gmail.com)<sup>1</sup>; [ityilo014@gmail.com](mailto:ityilo014@gmail.com)<sup>2</sup>; [oronubonghudson@gmail.com](mailto:oronubonghudson@gmail.com)<sup>3</sup>; [okonrachel305@gmail.com](mailto:okonrachel305@gmail.com)<sup>4</sup>

## ABSTRACT

The comparative analysis of nasal carriage antibiotic resistance of *Staphylococcus aureus* isolated from hospitalized and non-hospitalized patients within Urua Akpan community was carried out using standard bacteriological procedures. The results revealed staphylococcal count from hospitalized patients which ranged from 17 to 105 colonies per swab and 4 to 16 colonies per swab for non-hospitalized patients, with no Staphylococcal count in non-hospitalized patients swab sample 1 (NPH<sub>1</sub>) and swab sample 8 (NPH<sub>8</sub>). The frequency and percentage of occurrence of *S. aureus* from hospitalized patients revealed highest prevalence from HP<sub>6</sub> as 9(17.7%), HP<sub>9</sub> 8(15.8%), HP<sub>3</sub> 7(13.7%), HP<sub>5</sub> 6(11.8%), HP<sub>4</sub> recorded 5(9.8%), HP<sub>7</sub> and HP<sub>1</sub> had 4(7.8%) each, HP<sub>2</sub> and HP<sub>8</sub> indicated 3(5.9%) each, while sample 10 HP<sub>10</sub> recorded 2(3.9%) as the least. Non-hospitalized patients revealed low prevalence of *S. aureus* with sample 7 (NHP<sub>6</sub>) recorded the highest frequency and percentage of occurrence of 6(25.0%), NHP<sub>10</sub> 5(20.8%), NHP<sub>4</sub> 4(16.7%), NHP<sub>2</sub> 3(12.5%), NHP<sub>5</sub> and NHP<sub>9</sub> 2(8.3%) each, NHP<sub>3</sub> and NHP<sub>6</sub> indicated 1(4.2%) each, while HP<sub>1</sub> and HP<sub>8</sub> recorded no frequency and percentage of occurrence. The antibiotic susceptibility pattern of *Staphylococcus aureus* against ofloxacin antibiotics with zone of inhibition of hospitalized patients one (HP<sub>1</sub>) was 24mm at concentration of 90%, 19mm at 70% and 18mm at 50%. *Staphylococcus aureus* of (HP<sub>2</sub>) was 20mm and 18mm at concentration of 90% and 70%, HP<sub>4</sub> was sensitive to ofloxacin of 25mm at concentration of 90%, 20mm at 70%, and 18mm at 50%. HP<sub>8</sub> was 23mm and 18mm at 90% and 70% concentration. HP<sub>3</sub> was 18mm, HP<sub>6</sub> 19mm, HP<sub>7</sub> 20mm. Non-hospitalized patients swap samples revealed *Staphylococcus aureus* sensitive to ofloxacin at all concentrations, with highest zone of inhibition recorded in non-hospitalized patient swab sample four NHP<sub>4</sub> which ranged from 19-35mm, NHP<sub>3</sub> ranged from 18-31 mm, NHP<sub>6</sub> 19 - 32 mm, NHP<sub>7</sub> 18-31mm, NHP<sub>10</sub> 18-30mm, NHP<sub>9</sub> 18-26 mm, NHP<sub>5</sub> and NHP<sub>2</sub> had 17-26 mm and 18-29mm. The resistance rate among hospitalized patients at concentration of 50% and 70% are much higher than those in non-hospitalized patients.

KEYWORDS: *Staphylococcus aureus*, antibiotic resistance, hospitalized patients, non-hospitalized patients, nasal carriage, clinical isolates.

## INTRODUCTION

*Staphylococcus aureus* is a common microorganism found in the human body and is associated with various pathological conditions. Its pathogenicity is multifaceted, encompassing resistance to antimicrobial drugs and a high proficiency for biofilm formation (Krismer and Peschel, 2011). *Staphylococcus aureus* is a major pathogen in nosocomial and community-

acquired infections. Antibiotic-resistant *Staphylococcus aureus* is now the main source of community-acquired infections among individuals who have not been exposed to healthcare environments and its colonizes approximately 30% of the human population (Krismer and Peschel, 2011). Nasal colonization by this bacterium can lead to infections such as cellulitis, endocarditis, impetigo, osteomyelitis, pneumonia, septicemia, and toxic shock syndrome (TSS) (Nosheen *et al.*, 2017). The nasal carriage of *S. aureus* is influenced by various risk and demographic factors, including age, gender, immune system competency, ethnicity, chronic diseases, living conditions, and behavioral patterns (Sivaraman *et al.*, 2009).

Individuals who encounter a colonized patient or household members are at an increased risk of becoming colonized themselves (Fritz *et al.*, 2009). Antimicrobial resistance (AMR) presents a significant global challenge due to the rapid increase in infections caused by resistant microbes and the limited development of new antimicrobial medications (Prestinaci *et al.*, 2015). The emergence of multi-drugs resistant (MDR) strains of *S. aureus*, specifically methicillin-resistant *Staphylococcus aureus* (MRSA) has heightened concerns about the necessity for judicious antibiotic use to prevent the spread of these resistant strains (Bruzzeze *et al.*, 2016).

Risk factors for methicillin-resistant *Staphylococcus aureus* (MRSA) infection include the overuse of antimicrobial agents, hospitalization, close contact with infected or colonized individuals, and various medical conditions. Additional risk factors comprise diabetes, advanced age, the presence of indwelling devices, intravenous drug use, and immune-compromised states. Understanding the modes of transmission, colonization persistence, and antimicrobial patterns is crucial for developing effective prevention and control measures (Okamo *et al.*, 2016).

Health care giver, visitors and non-hospitalized individual frequently interact with hospitalized patients and health personnel who may be colonized by *S. aureus*. The sharing of personal items and suboptimal sanitary conditions within these hospital environments may raise significant public health concerns. This is particularly alarming because hospital environment can serve as reservoirs for the transmission of resistant bacteria (Fritz *et al.*, 2009). *S. aureus* strains have developed resistance to  $\beta$ -lactam antibiotics, including MRSA. The organism acquires resistance through the insertion of the *mecA* gene at a precise location on its chromosome, and the *mecA* encodes an alternative penicillin-binding protein with a low affinity for semisynthetic drugs, such as methicillin, nafcillin, and oxacillin (Lu *et al.*, 2008).

MRSA strains spread quickly in vulnerable hospitalized (exposed) and healthy non-exposed individuals, profoundly changing the current therapeutic options for the prevention and treatment of *staphylococcal* infections (Sadar and Bradley, 2008). Healthy carrier act as a reservoir for the spread of *S. aureus* to uncolonized susceptible patients. Besides, the chances of the transmission of MRSA from the medical care giver carriers to the community are a great hazard. Hospital staff, are among the groups living in crowded and antibiotic expose conditions, which could make them more vulnerable to inadequate care and possibly at higher risk for MRSA colonization. However, little is known about nasal carriage of other antibiotics resistance *Staphylococcus aureus* (ARSA) among hospitalized and non-hospitalized patients (Askarian *et al.*, 2009). Therefore, this study aimed to assess *Staphylococcus aureus* nasal carriage rate, and antimicrobial susceptibility patterns among hospitalized patients, non-hospitalized patients who visited different health facility within Urua Akpan community and their resistant patterns to commonly prescribed antibiotics.

## **MATERIAL AND METHODS**

Two sets of nasal swab samples were collected from two sets of persons within Urua Akpan Community in Essien Udim Local Government Area of Akwa Ibom State. Ten (10) samples

from admitted patients from different hospital wards (men, women and children) of St. Mary's Hospital Urua Akpan and ten (10) samples from healthy persons who have been on antibiotics medication within last 7 days, pro-to-sample collection, within Urua Akpan Community. All samples were obtained using sterile cotton swab pre-wetted with sterile physiological saline to rotate twice in the vestibule of both anterior nares of both persons and aseptically placed back in each of the cabinet, labeled appropriately and transported immediately to Microbiology Laboratory of the Department of Biological Sciences, Akwa Ibom State Polytechnic, Ikot Osurua for further analysis. The specimens were cultured using Manitol salt agar and incubated at 37°C for 48 hours. Viable colonies were counted and expressed as colony per swab. *Staphylococcus aureus* isolates were identified based on colony morphology, microscopic examination and biochemical activities. Antibiotic susceptibility patterns were determined with the guidelines of the CLSI, using the Kirby-Bauer disk diffusion method (CLSI, 2005). Antibiotic resistance susceptibility were tested with oxacillin antibiotics (90%, 70% and 50%) using Muller-Hinton agar plates inoculated with a suspension (equivalent to 0.5 McFarland standards) of the *S. aureus* clinical isolates. The plates were incubated at 35°C for 24 hours and inhibition zones were measured (Skov *et al.*, 2003). The Clinical Laboratory Standards Institute (CLSI) 2005 criteria were used for interpretation.

## RESULTS AND DISCUSSION OF RESULTS

The comparative analysis of nasal carriage antibiotic resistance of *Staphylococcus aureus* isolated from hospitalized and non-hospitalized patients within Urua Akpan community was carried out and the results of colony counts per swab as presented in table 4.1, revealed staphylococcal count from hospitalized patients ranging from 17 to 105 colonies per swab and 4 to 16 colonies per swab for non- hospitalized patients. Table 2 shows the morphologies and biochemical characteristics of *Staphylococcus aureus* obtained from hospitalized and non-hospitalized patients within Urua Akpan community.

Table 3 shows the results of *S. aureus* per swab of nasal carriage of hospitalized patients and non-hospitalized patients within Urua Akpan Community. The study revealed high frequency and percentage of occurrence of *S. aureus* from hospitalized patients, with sample 6 (HP<sub>6</sub>) recorded the highest prevalence of 9(17.7%), followed by HP<sub>9</sub> which had 8(17.7%), HP<sub>3</sub> indicated 7(13.7%), HP<sub>5</sub> had 6(11.8%), HP<sub>4</sub> recorded 5(9.8%), HP<sub>1</sub> and HP<sub>7</sub> indicated 4(7.8%) each, HP<sub>2</sub> and HP<sub>8</sub> recorded 3(5.9%) each, while HP<sub>10</sub> indicated 2(3.9%) as the least. Non-hospitalized patients revealed low prevalence of *S. aureus* with sample 7 (NHP<sub>7</sub>) recorded the highest frequency and percentage occurrence of 6(25.0%), followed by NHP<sub>10</sub> which had 5(20.8%), NHP<sub>4</sub> indicated 4(16.7%), NHP<sub>2</sub> had 3(12.5%), NHP<sub>9</sub> recorded 2(3.8%), NHP<sub>3</sub> and NHP<sub>6</sub> recorded 1(4.2%) each, while sample NHP<sub>1</sub> and NHP<sub>8</sub> recorded no frequency and percentage occurrence.

Table 4 shows the antibiotic susceptibility pattern of *Staphylococcus aureus* against ofloxacin antibiotics with zone of inhibition. *Staphylococcus aureus* obtained from nasal swab sample of hospitalized patients one (PH<sub>1</sub>) was sensitive to ofloxacin with zone of inhibition 24mm at concentration of 90%, 19mm at concentration 70% and 18mm at concentration of 50%. *Staphylococcus aureus* obtained from nasal swab sample of hospitalized patients four (HP<sub>4</sub>) were sensitive to ofloxacin with zone of inhibition of 25mm at concentration of 90%, 20mm at 70% concentration, and 18mm at 50% concentration. *Staphylococcus aureus* obtained from nasal swab sample of hospitalized patients two (HP<sub>2</sub>) recorded zone of inhibition of 20mm and 18mm at concentration of 90%. Hospitalized patients eight (HP<sub>8</sub>) recorded zone of inhibition of 23mm and 18mm at 90%, hospitalized patients three (HP<sub>3</sub>), patients six (HP<sub>6</sub>) and patients seven (HP<sub>7</sub>) were sensitive to ofloxacin only at concentration of 90% with zone of inhibition of 18mm, 19mm and 20mm respectively.

Non-hospitalized patients swap samples in Urua Akpan community revealed that all isolated *Staphylococcus aureus* were sensitive to ofloxacin at all concentration, with highest zone of inhibition recorded in patient swab sample four (NHP<sub>4</sub>) which ranged from 19-35mm, NHP<sub>3</sub> ranged from 18 - 31mm, NHP<sub>6</sub> ranged from 19 - 32mm, NHP<sub>7</sub> ranged from 18 - 31mm, NHP<sub>10</sub> ranged from 18- 30mm, NHP<sub>9</sub> ranged from 18- 26 mm, NHP<sub>5</sub> and NHP<sub>2</sub> had zone of inhibition ranging from 17- 26mm and 18-29 mm respectively.

**Table 1 shows the colony count per swab of nasal carriage of hospitalized patients and non-hospitalized patients within Urua Akpan Community**

Nasal carriage of hospitalized patients	Colony count per swab	Nasal carriage of non-hospitalized patients	Colony count per swab
HP <sub>1</sub>	17	NPH <sub>1</sub>	-
HP <sub>2</sub>	22	NPH <sub>2</sub>	11
HP <sub>3</sub>	65	NPH <sub>3</sub>	6
HP <sub>4</sub>	25	NPH <sub>4</sub>	13
HP <sub>5</sub>	85	NPH <sub>5</sub>	4
HP <sub>6</sub>	105	NPH <sub>6</sub>	8
HP <sub>7</sub>	76	NPH <sub>7</sub>	17
HP <sub>8</sub>	64	NPH <sub>8</sub>	-
HP <sub>9</sub>	47	NPH <sub>9</sub>	7
HP <sub>10</sub>	75	NPH <sub>10</sub>	16

**Keys**

- - No growth recorded
- HP - Hospital Patients from different wards in St. Mary's Hospital Urua Akpan
- NPH - Non-hospitalized patients within Urua Akpan Community.

**Table 2: Morphological and Biochemical Characteristics of isolate from Hospitalized and Non-hospitalized Patients swap samples in Urua Akpan community, Essien Udim L.G. A. Akwa Ibom State**

Sample code	Morphology characteristics	Grams stain	Coagulase	Catalase	Oxidase	Motility	Spores	Sugar fermentation				Probable organism
								Glucose	Lactose	Maltose	Sucrose	
HP <sub>1</sub>	Yellow, raised transparent, circular smooth	+	+	+	-	-	-	AG	AG	AG	AG	<i>Staphylococcus aureus</i>
HP <sub>2</sub> /NPH <sub>2</sub>	Yellow, raised, transparent, circular, smooth	+	+	+	-	-	-	AG	AG	AG	AG	<i>Staphylococcus aureus</i>

HP <sub>3</sub> /NPH <sub>3</sub>	Yellow, raised, transparent, circular, smooth.	+	+	+	-	-	-	AG	AG	AG	AG	<i>Staphylococcus aureus</i>
HP <sub>4</sub> /NPH <sub>4</sub>	Yellow, flat, Transparent, circular, smooth	+	+	+	-	-		AG	AG	AG	AG	<i>Staphylococcus aureus</i>
HP <sub>5</sub> /NPH <sub>5</sub>	Yellow, circular transparent. Raised, smooth	+	+	+	-	-	-	AG	AG	AG	AG	<i>Staphylococcus aureus</i>
HP <sub>6</sub> /NPH <sub>6</sub>	Yellow, irregular, transparent, raised,	+	+	+	-	-	-	AG	AG	AG	AG	<i>Staphylococcus aureus</i>
HP <sub>7</sub> /NPH <sub>7</sub>	Yellow, circular transparent, raised, smooth	+	+	+	-	-	-	AG	AG	AG	AG	<i>Staphylococcus aureus</i>
HP <sub>8</sub>	Yellow, circular transparent, raised, smooth	+	+	+	-	-	-	AG	AG	AG	AG	<i>Staphylococcus aureus</i>
HP <sub>9</sub> /NPH <sub>9</sub>	Yellow, circular transparent, raised, smooth	+	+	+	-	-	-	AG	AG	AG	AG	<i>Staphylococcus aureus</i>
HP <sub>9</sub> /NPH <sub>9</sub>	Yellow, circular transparent, raised, smooth	+	+	+	-	-	-	AG	AG	AG	AG	<i>Staphylococcus aureus</i>

**Keys:**

- HP - Hospitalized Patients swap samples in Urua Akpan community, Essien Udim L.G. A. Akwa Ibom State
- NPH - Non-hospitalized Patients swap samples in Urua Akpan community, Essien Udim L.G.A. Akwa Ibom State
- AG - Acid and Gas production
- + - Positive
- - Negative

**Table 3 Shows frequency and percentage of occurrence of *S. aureus* per swab of nasal carriage of hospitalized patients and non-hospitalized patients within Urua Akpan Community**

Isolates from hospitalized patients			Isolates from hospitalized patients		
Sample Code	Frequency of occurrence (n=51)	Percentage of occurrence (%)	Sample Code	Frequency of occurrence (n=24)	Percentage of occurrence (%)
HP <sub>1</sub>	4	7.8	NPH <sub>1</sub>	-	0
HP <sub>2</sub>	3	5.9	NPH <sub>2</sub>	3	12.5
HP <sub>3</sub>	7	13.7	NPH <sub>3</sub>	1	4.2
HP <sub>4</sub>	5	9.8	NPH <sub>4</sub>	4	16.7
HP <sub>5</sub>	6	11.8	NPH <sub>5</sub>	2	8.3
HP <sub>6</sub>	9	17.7	NPH <sub>6</sub>	1	4.2
HP <sub>7</sub>	4	7.8	NPH <sub>7</sub>	6	25.0
HP <sub>8</sub>	3	5.9	NPH <sub>8</sub>	-	0
HP <sub>9</sub>	8	15.7	NPH <sub>9</sub>	2	8.3
HP <sub>10</sub>	2	3.9	NPH <sub>10</sub>	5	20.8

**Keys**

- HP - Hospital Patients from different wards in St. Mary's Hospital Urua Akpan  
 NPH - Non-hospitalized patients within Urua Akpan Community.

**Table 4: Antibiotic susceptibility pattern of *Staphylococcus aureus* against ofloxacin antibiotics with zone of inhibition**

Code for Isolated <i>Staphylococcus aureus</i>	Zone of Inhibition of <i>Staphylococcus aureus</i> against ofloxacin antibiotic (mm)		
	90%	70%	50%
HP <sub>1</sub>	24	19	18
HP <sub>2</sub>	21	18	8
HP <sub>3</sub>	18	14	-
HP <sub>4</sub>	25	20	18
HP <sub>5</sub>	15	12	-
HP <sub>6</sub>	19	11	7
HP <sub>7</sub>	20	14	-
HP <sub>8</sub>	23	18	8
HP <sub>9</sub>	14	10	-
HP <sub>10</sub>	16	12	-
NHP <sub>2</sub>	27	21	18
NHP <sub>3</sub>	31	21	19
NHP <sub>4</sub>	35	23	19
NHP <sub>5</sub>	26	21	17
NHP <sub>6</sub>	32	22	19
NHP <sub>7</sub>	31	21	17
NHP <sub>9</sub>	26	20	18
NHP <sub>10</sub>	30	20	18

**Keys**

- HP - Hospitalized Patients swap samples obtained St. Mary's Hospital Urua Akpan, Essien Udim L.G.A.  
 NHP - Non-hospitalized Patients swap samples in Urua Akpan community, Essien Udim

## Discussion

The comparative analysis of nasal carriage of *Staphylococcus aureus* emphasizes the public health significance of understanding the prevalence and antibiotic resistance associated with this pathogen among different patient populations. The results from the study indicate that the staphylococcal count among hospitalized patients ranged from 17 to 105 colonies per swab, significantly higher compared to non-hospitalized patients, which only reflected counts from 4 to 16 colonies per swab. Lower staphylococcal counts observed in non-hospitalized patients could be attributed to fewer exposure opportunities to potentially contaminated environments present in healthcare settings. Non-hospitalized individuals typically encounter fewer invasive procedures and have increased exposure to a healthy living environment, which may contribute to lower nasopharyngeal colonization rates of *Staphylococcus aureus* and non-hospitalized subjects are usually healthier, with fewer co-morbidities that may promote colonization persistence which supported the work of Miller and High, (2012).

Hospitalized patients often undergo various medical interventions, such as surgeries or prolonged admissions that provide opportunities for colonization and infection by antibiotic-resistant strains. Hospitalized patients are generally more vulnerable due to existing health conditions and the potential disruption of their natural microbial flora caused by frequent antibiotic usage which correlates with the work of Hassan *et al.* (2019). Additionally, exposure to invasive devices, such as catheters and ventilators, increases the risk of acquiring *Staphylococcus aureus*, including multidrug-resistant strains, from the healthcare environment (Michaels *et al.*, 2017). The hospital setting also harbors a diverse pool of antibiotic-resistant bacteria due to selective pressure on pathogens caused by antibiotic use, making it conducive for the survival of resistant strains (Raza *et al.*, 2018).

The variation in the frequency and percentage occurrence of *S. aureus* nasal carriage among hospitalized and non-hospitalized patients in the Urua Akpan Community revealed that hospitalized patients carry a higher prevalence of *S. aureus* due to their compromised immune systems and underlying health conditions. Hospital environments often present higher risks for bacterial colonization and infection due to the close proximity of patients, the presence of medical devices, and increased exposure to antibiotic-resistant strains (Miller and High, 2012).

Antibiotic use among hospitalized patients may also influence the flora of nasal carriage proportionally. While some antibiotics target *S. aureus* directly, others can disrupt the microbiome, potentially allowing for colonization by antibiotic-resistant strains. This dynamic is reflected in the differing isolation rates, as seen in the high occurrence among hospitalized patients. Non-hospitalized individuals might have better immune responses and less exposure to antibiotics overall, which could explain the lower occurrence rates (Gholizadeh and Ebrahimi, 2017).

The findings of this study closely align with other research efforts that have documented a higher nasal carriage prevalence in hospitalized patients compared to non-hospitalized individuals. A study conducted by Kasa *et al.* (2018) in a Nigerian tertiary hospital reported that hospitalized patients exhibited a higher nasal carriage of *Staphylococcus aureus*, with a mean count significantly greater than that observed in community-dwelling individuals. Similarly, Okafo *et al.* (2021) demonstrated that among surgical patients, the prevalence of nasal *S. aureus* was notably higher due to prolonged hospital stays and frequent antibiotic therapies. Furthermore, a comparative analysis by Thapliyal *et al.* (2020) found that non-hospitalized individuals had lower rates of nasal carriage, supporting the notion that the community environment promotes a healthier microbiome compared to healthcare settings. Hence, the increased incidence of *Staphylococcus aureus* nasal carriage linked to hospitalized patients highlights a pressing public health concern, particularly regarding antibiotic

resistance. This finding is consistent with other literature demonstrating the risks associated with healthcare exposure. Continuous monitoring and infection control strategies remain essential in minimizing both nasal carriage and subsequent infections caused by antibiotic-resistant *Staphylococcus aureus* within hospital settings.

The rise of antibiotic-resistant *Staphylococcus aureus* is a major public health challenge, particularly in understanding its prevalence in different populations, such as hospitalized versus non-hospitalized patients. This analysis provides insights into the antibiotic susceptibility patterns of *Staphylococcus aureus* against ofloxacin, highlighting a significant discrepancy between these two groups regarding their response to antibiotics. The results of the antibiotic susceptibility pattern revealed varied zones of inhibition among *Staphylococcus aureus* isolates from hospitalized and non-hospitalized patients in the Urua Akpan community. Hospitalized patients showed zones of inhibition against ofloxacin ranging from 18 mm to 27 mm at different concentrations, while non-hospitalized patients demonstrated a more significant range, with values reaching up to 47 mm at a 90% concentration (NHP<sub>4</sub>). This indicates a notable difference in antibiotic susceptibility patterns.

The higher susceptibility observed in non-hospitalized patients can be attributed to less antibiotic exposure. Non-hospitalized individuals generally have had less prior exposure to antibiotics, which preserves their microbiota's effectiveness against pathogens. Continuous antibiotic use in healthcare settings often leads to selection pressure for resistant strains which correlate with the work of Levy *et al.* (2015). Non-hospitalized patients often present with fewer co-morbidities compared to hospitalized patients, leading to a more robust immune response that can effectively combat pathogens as reported by Boyce and Leggett, (2017). Environmental factors could also contribute to high level of sensitivity, since the non-hospitalized group is less likely to encounter the same levels of pathogen load and resistant strains that clinic and hospital environments might harbor, resulting in fewer resistant bacteria (Gandra *et al.*, 2016).

Hospitalized patients are frequently exposed to broad-spectrum antibiotics. This repeated exposure promotes survival of resistant strains, while community individuals experience less antibiotic pressure, allowing isolates to remain largely susceptible. Hospital environments are reservoirs for multidrug-resistant strains, including MRSA. According to World Health Organization (WHO, 2020), healthcare facilities are major hubs for antimicrobial resistance transmission and community individuals generally have fewer invasive procedures and underlying illnesses that predispose them to colonization by resistant strains, hence the significantly larger inhibition zones observed in isolates from non-hospitalized patients, compare to isolates from hospitalized patients.

*Staphylococcus aureus* employs various mechanisms to exhibit antibiotic resistance. Beta-lactamase is an enzymes produced by *Staphylococcus aureus* which breaks down beta-lactam antibiotics and can contribute to resistance (Thompson *et al.*, 2018). Resistance can occur through mutations that alter the antibiotic targets, such as penicillin-binding proteins (PBPs), hence leads to modification of antibiotics targeted sites (Peacock and Paterson, 2015).

Efflux pumps are antibiotic mechanisms where bacteria actively transport antibiotics out of the cell, reducing the effectiveness of antibiotics on cell targeted sites. Transferable resistance genes enhance survival in antibiotic-rich environments. These mechanisms are more prevalent in hospital isolates due to intense antibiotic exposure (Li *et al.*, 2015).

The findings in this study resonate with other literature regarding antibiotic resistance patterns in *Staphylococcus aureus*. Okafo *et al.* (2021) reported higher antibiotic sensitivity in community settings compared to hospital settings, aligning with our data on increased susceptibility among non-hospitalized patients. Similarly, Kasa *et al.* (2018) found that

hospital-associated strains exhibited lower susceptibility compared to their community counterparts, attributing this to increased selective pressure associated with hospitalization, which also agreed with the results of this study.

A study by Egyir *et al.* (2014) found that community-based isolates of *S. aureus* in Germany showed high susceptibility to fluoroquinolones, whereas hospital strains exhibited higher resistance rates which are in line with the antibiotics susceptibility pattern of this study. Similarly, Alghaithy *et al.* (2000) also reported significantly greater fluoroquinolone resistance among hospital personnel compared to non-hospital workers. The decreasing inhibition zones in hospitalized isolates at 70% and 50% concentrations suggested emerging high-level resistance, reduced drug permeability, partial target mutation and heterogeneous bacterial populations associated with hospitalized patients, while community (non-hospitalized patients) isolates maintained high zones across concentrations, indicating absence of resistance determinants. This analysis underscores the importance of distinguishing antimicrobial susceptibility patterns in *Staphylococcus aureus* between hospitalized and non-hospitalized patients. The findings advocate for targeted infection control measures in hospital settings and suggest that maintaining a balance of antibiotic usage in non-hospitalized populations may help reduce the prevalence of resistant strains. Continuous surveillance and antimicrobial stewardship programs are essential in mitigating the spread of antibiotic resistance.

## Conclusion

The comparative analysis of nasal carriage antibiotic resistance of *Staphylococcus aureus* isolated from hospitalized and non-hospitalized patients within the Urua Akpan community revealed significant differences in bacterial counts and susceptibility to ofloxacin. The staphylococcal counts from hospitalized patients indicated a higher frequency of *S. aureus* carriage in this group compared to non-hospitalized patients. This suggests that hospitalized patients may possess a greater risk of antibiotic-resistant strains due to various factors such as frequent exposure to healthcare settings and antibiotic use. The hospitalized patients exhibited varying sensitivities to ofloxacin, with some strains demonstrating decreased susceptibility, all strains from non-hospitalized patients were susceptible across all tested concentrations. This variability underscores an important public health concern, as it indicates that non-hospitalized individuals may harbor more susceptible strains of *S. aureus*, potentially reducing the risk of resistant infections. Based on the results of this finding, it could be recommended that regular monitoring of *Staphylococcus aureus* in both hospitalized and non-hospitalized patients within the Urua Akpan community should be carried out to track trends in antimicrobial resistance over time, prudent use of antibiotics in healthcare settings should be regulated in order to prevent the development of resistance, increase awareness concerning the risks of antibiotic resistance among both healthcare providers and the community should be carried out effectively and effective programme strengthening infection prevention and control protocols in healthcare facilities should be facilitated to reduce the transmission of antibiotic-resistant strains.

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# Decolonizing Educational Leadership: Indigenous Knowledge Systems and Legal Recognition in Public Secondary Schools in Cross River State, Nigeria

AKATA, Charles Ekpung, Ph.D  
Empirical Research Institute of Nigeria, Uyo  
[drakata@erin.com.ng](mailto:drakata@erin.com.ng)

## ABSTRACT

*This study examined the integration of Indigenous Knowledge Systems (IKS) into educational leadership practices and their impact on school governance and decision-making in public secondary schools in Cross River State, Nigeria. It also explored the role of legal recognition and policy support in facilitating IKS integration and the contribution of principals to culturally responsive and community-based education. A descriptive survey design was employed, targeting all 325 principals in public secondary schools. Data were collected via a structured four-point Likert scale questionnaire and analyzed using Chi-square tests. Findings revealed a significant association between IKS integration and educational leadership practices ( $\chi^2 = 15.72$ ,  $df = 6$ ,  $p = 0.015$ ), indicating that principals who actively incorporate indigenous knowledge enhance culturally relevant leadership and school governance. Legal recognition and policy support were significantly linked to IKS integration ( $\chi^2 = 18.46$ ,  $df = 6$ ,  $p = 0.005$ ), emphasizing the role of formal frameworks in sustaining indigenous knowledge. Additionally, principals' leadership practices significantly influenced the promotion of culturally responsive and community-based education ( $\chi^2 = 14.89$ ,  $df = 6$ ,  $p = 0.022$ ), demonstrating that active engagement with community traditions strengthens educational relevance and inclusivity. The study recommends institutionalizing IKS through policy support and encourages principals to continue fostering community-based practices to improve educational outcomes and cultural preservation in Cross River State.*

KEYWORDS: Indigenous Knowledge Systems, educational leadership, school governance, Cross River State, culturally responsive education

## Introduction

Education in Nigeria, including Cross River State, has largely developed within a colonial framework that emphasizes Western knowledge systems and leadership models. This has led to the marginalization of Indigenous Knowledge Systems, which traditionally guided community education through oral traditions, apprenticeship, and cultural practices. In Cross River State, indigenous knowledge remains relevant in areas such as environmental management, social cohesion, and moral development, particularly within rural communities.

Empirical evidence indicates that indigenous knowledge contributes to sustainable resource management and environmental awareness in Cross River communities (Brownson, Chigbu, and Osazuwa, 2024; Odok, 2023). Similarly, studies in the Ikom Education Zone show that indigenous educational practices influence community values and learners' understanding of sustainability (Nanghata, 2025). Despite these benefits, formal educational leadership structures have not adequately integrated indigenous knowledge into school governance or practice, creating a disconnect between schools and their host communities.

A major challenge is the limited legal recognition of indigenous knowledge within Nigeria's education system. Although national policies acknowledge cultural heritage, they provide weak legal mechanisms for incorporating indigenous perspectives into leadership and decision making. In Cross River State, gaps in policy implementation further restrict the inclusion of indigenous stakeholders such as community elders and traditional leaders in educational governance (Ogbiji and Ogbiji, 2024).

The increasing influence of globalization and formal schooling has also contributed to the erosion of indigenous knowledge among younger generations. This situation underscores the need for decolonizing educational leadership by integrating indigenous knowledge within legally supported frameworks. Such an approach can enhance educational relevance, strengthen community participation, and promote sustainable development.

This study therefore examines how educational leadership in Cross River State can incorporate Indigenous Knowledge Systems within existing legal frameworks, and the implications for effective and culturally responsive education.

### **Statement of the Problem**

Educational leadership in Cross River State remains largely shaped by Western-oriented frameworks inherited from colonial systems, with limited integration of Indigenous Knowledge Systems. This has created a disconnect between formal schooling and the socio-cultural realities of local communities, where indigenous knowledge continues to play a vital role in daily life and development.

Although indigenous knowledge has been shown to support environmental sustainability, moral development, and community cohesion, it is rarely incorporated into school leadership and decision-making processes (Brownson, Chigbu, and Osazuwa, 2024; Nanghata, 2025). A major contributing factor is the lack of strong legal provisions to institutionalize indigenous knowledge within the formal education system, alongside weak policy implementation that excludes community stakeholders from educational governance (Ogbiji and Ogbiji, 2024).

This situation is further worsened by globalization and modernization, which continue to erode indigenous knowledge among younger generations. The problem of this study, therefore, is the inadequate integration of Indigenous Knowledge Systems into educational leadership due to weak legal recognition and implementation gaps in Cross River State, resulting in reduced educational relevance and limited community engagement.

### **Specific Objectives**

The study seeks to:

1. Examine the integration of Indigenous Knowledge Systems into educational leadership practices and their influence on school governance and decision-making processes.
2. Assess the level of legal recognition and policy support for Indigenous Knowledge Systems in the education sector.
3. Evaluate the role of educational leaders in promoting culturally responsive and community-based education.

### **Research Questions**

1. What is the level of integration of Indigenous Knowledge Systems into educational leadership practices in public secondary schools in Cross River State?

2. How does legal recognition and policy support facilitate the integration of Indigenous Knowledge Systems into the education sector in Cross River State?
3. How do principals promote culturally responsive and community-based education in public secondary schools in Cross River State?

### **Null Hypotheses**

H<sub>01</sub>: There is no significant association between the integration of Indigenous Knowledge Systems and educational leadership practices in public secondary schools in Cross River State.

H<sub>02</sub>: There is no significant association between legal recognition and policy support and the integration of Indigenous Knowledge Systems into the education sector in Cross River State.

H<sub>03</sub>: There is no significant association between principals' leadership practices and the promotion of culturally responsive and community-based education in public secondary schools in Cross River State.

### **Literature Review**

#### **Indigenous Knowledge Systems**

Indigenous Knowledge Systems (IKS) refer to the cumulative body of knowledge, skills, beliefs, practices, and cultural norms developed and sustained by local communities over generations. This knowledge is deeply rooted in the social, environmental, and spiritual contexts of the community and is transmitted through oral traditions, storytelling, apprenticeship, rituals, and community participation. In Cross River State, IKS encompasses a wide range of practices, including traditional governance structures, conflict resolution mechanisms, moral and ethical instruction, environmental management techniques, indigenous agricultural methods, and local arts and crafts (Brownson, Chigbu, & Osazuwa, 2024; Odok, 2023).

IKS plays a critical role in shaping community identity and sustaining local cultural heritage. It provides practical solutions to everyday challenges, such as managing natural resources, mitigating environmental risks, and promoting social cohesion. Moreover, IKS embodies values, ethics, and social norms that guide behavior, decision-making, and community interactions, making it a vital component of communal life.

In the context of education, IKS offers a rich resource for enhancing learning relevance and cultural responsiveness. Schools that integrate indigenous knowledge into curricula and leadership practices enable students to connect academic concepts with local realities. For instance, environmental education can incorporate traditional forest management practices, while social studies can include local histories, folklore, and community governance systems. By doing so, education becomes both contextually meaningful and aligned with the lived experiences of learners (Nanghata, 2025).

Despite its value, IKS has historically been marginalized within formal education systems, which often prioritize Western knowledge and epistemologies. This marginalization risks cultural erosion and reduces the relevance of schooling for local communities. Recognizing and integrating IKS into educational leadership and policy is therefore essential for decolonizing education, promoting community participation, and ensuring that schools contribute to sustainable social and cultural development.

In Cross River State, the effective use of IKS within schools not only preserves cultural heritage but also strengthens governance, decision-making, and community engagement. Educational

leaders who embrace IKS can foster culturally responsive teaching, participatory governance, and policies that reflect local realities, creating an education system that is both academically rigorous and socially relevant.

### **Indigenous Knowledge Systems and Educational Leadership Practices**

The integration of Indigenous Knowledge Systems (IKS) into educational leadership entails the deliberate inclusion of local cultural, social, and moral knowledge into school management, policy formulation, and decision-making processes. In Cross River State, indigenous knowledge has long been embedded in the governance structures of local communities, guiding social regulation, conflict resolution, environmental management, and moral education. This knowledge is transmitted through traditional mechanisms, including storytelling, rituals, apprenticeship, and guidance from community elders. When educational leaders incorporate these indigenous systems into formal school leadership, decision-making becomes more contextually grounded, culturally sensitive, and responsive to the unique needs of the communities they serve (Brownson, Chigbu, and Osazuwa, 2024; Nanghata, 2025).

The influence of IKS on school governance is significant because it shapes the principles and practices that guide leadership decisions. Leaders who draw on indigenous knowledge are more likely to engage in participatory governance, consult community stakeholders, and implement policies that align with local values and expectations. This approach enhances transparency, accountability, and trust within schools, bridging the gap between formal education and community life. Furthermore, incorporating indigenous knowledge into decision-making processes allows schools to address local challenges more effectively, including environmental sustainability, resource management, and the promotion of social cohesion. Empirical studies have demonstrated that schools that recognize and integrate IKS experience higher levels of community involvement, improved student engagement, and more effective problem-solving strategies (Odok, 2023).

In addition, integrating IKS into educational leadership contributes to the decolonization of education by challenging the dominance of Western-centric administrative models. It acknowledges the value of local knowledge systems and cultural practices, promoting an inclusive approach to leadership that respects and leverages the experiences of community members. Educational leaders who embrace this integration serve not only as administrators but also as cultural mediators who connect formal schooling with indigenous wisdom, ensuring that educational policies and practices reflect both global standards and local realities.

In the context of Cross River State, exploring the integration of IKS into educational leadership provides critical insights into how schools can become more culturally relevant and socially responsive. It underscores the potential of decolonized leadership to strengthen school governance, foster community collaboration, and preserve indigenous knowledge for future generations. Understanding the mechanisms through which IKS influence decision-making processes is therefore essential for developing educational frameworks that are equitable, contextually appropriate, and sustainable.

### **Role of Educational Leaders in Promoting Culturally Responsive and Community-Based Education**

Educational leaders play a pivotal role in bridging formal schooling with the cultural, social, and moral realities of the communities they serve. In Cross River State, schools operate in culturally diverse settings, where community traditions, values, and indigenous knowledge remain central to daily life. Leaders who adopt a culturally responsive approach recognize the importance of aligning school policies, management practices, and teaching methods with these local realities. This involves not only acknowledging the value of Indigenous Knowledge

Systems but also actively incorporating them into leadership decisions, school governance, and curriculum implementation (Brownson, Chigbu, & Osazuwa, 2024; Nanghata, 2025).

Culturally responsive educational leadership enhances community engagement by creating inclusive platforms for dialogue and decision-making. Leaders who consult with community elders, traditional rulers, parents, and local stakeholders ensure that educational initiatives are contextually relevant and socially acceptable. Such practices foster trust, cooperation, and mutual accountability between schools and the communities they serve. In addition, educational leaders serve as role models who demonstrate respect for indigenous values, thereby encouraging teachers and students to appreciate local knowledge and cultural heritage.

Moreover, community-based education emphasizes experiential learning and practical engagement with the environment and society. Educational leaders facilitate programmes that integrate local culture, history, and environmental knowledge into school activities, promoting skills and competencies that are meaningful within the community context. For example, integrating traditional environmental management techniques, folk narratives, and local ethical principles into classroom instruction enhances both academic learning and cultural preservation (Odok, 2023).

The role of educational leaders also extends to advocating for institutional and policy reforms that support culturally responsive education. Leaders can influence curriculum development, teacher training, and resource allocation to ensure that indigenous knowledge is recognized and valued within formal education systems. By fostering an environment where indigenous knowledge informs teaching, governance, and school management, educational leaders contribute to the decolonization of education and the empowerment of local communities.

In Cross River State, the promotion of culturally responsive and community-based education by school leaders is critical for bridging the gap between formal schooling and indigenous knowledge systems. It ensures that education is not only academically relevant but also socially and culturally meaningful. By actively integrating community values into leadership practices, educational leaders enhance student engagement, strengthen school-community partnerships, and preserve the cultural heritage that underpins sustainable local development.

### **The Role of Educational Leaders in Promoting Culturally Responsive and Community-Based Education**

Educational leaders hold a critical position in shaping schools as spaces where learning is both academically rigorous and culturally relevant. In the context of Cross River State, Nigeria, schools operate within culturally diverse communities where Indigenous Knowledge Systems (IKS) remain a vital component of social, moral, and environmental life. Educational leaders, therefore, must move beyond traditional administrative functions to embrace roles as cultural mediators, policy advocates, and community collaborators. Their responsibilities involve actively recognizing, valuing, and integrating indigenous knowledge, practices, and local perspectives into school leadership, curriculum development, and pedagogical strategies (Brownson, Chigbu, & Osazuwa, 2024; Nanghata, 2025).

A central aspect of this role is fostering participatory governance. Leaders facilitate meaningful engagement with community stakeholders such as elders, traditional rulers, parents, and local organizations, ensuring that school policies and decisions reflect the cultural, social, and environmental realities of the community. By involving these stakeholders, educational leaders enhance transparency, accountability, and trust, bridging the gap between formal schooling and community life. Participatory governance also allows schools to benefit from local

expertise, particularly in areas like conflict resolution, moral instruction, and environmental stewardship, which are deeply rooted in indigenous knowledge.

Educational leaders also drive the integration of IKS into curriculum and instructional practices. This may include incorporating local histories, folklore, environmental management techniques, traditional arts, and ethical principles into teaching and learning processes. Such integration promotes experiential learning and contextual understanding, enabling students to relate academic content to real-world applications within their communities. For example, teaching local agricultural practices or forest conservation methods alongside science lessons strengthens both academic competence and cultural awareness (Odok, 2023).

Another crucial dimension of the educational leader's role is advocacy for policy and institutional support. Leaders can influence school boards, government agencies, and education policymakers to create frameworks that formally recognize and support the use of indigenous knowledge in school governance, curriculum design, and teacher professional development. By advocating for resources, training, and policies that legitimize and institutionalize indigenous knowledge, leaders ensure that culturally responsive and community-based education is sustainable and not dependent on individual initiative alone.

Furthermore, promoting culturally responsive education helps address broader social challenges, such as cultural alienation, erosion of local values, and disengagement from schooling. By positioning schools as sites where local culture, knowledge, and values are respected and transmitted, educational leaders foster a sense of identity and belonging among students. This not only enhances academic motivation and participation but also contributes to the preservation and intergenerational transmission of indigenous knowledge systems.

In the context of Cross River State, the role of educational leaders is therefore multi-faceted: they are administrators, cultural mediators, policy advocates, and community liaisons. Their leadership directly impacts the relevance, inclusivity, and effectiveness of education. By actively promoting culturally responsive and community-based education, leaders ensure that schools do not merely transmit universal knowledge but also empower students to understand, appreciate, and contribute to their local communities. In this way, educational leadership becomes a tool for decolonizing education, strengthening community engagement, and ensuring that indigenous knowledge systems remain vibrant and influential within contemporary schooling.

## **Theoretical Framework**

The study is anchored on Paulo Freire's Theory of Critical Pedagogy and Horner's Participatory Leadership Theory, which together provide a strong conceptual foundation for examining the integration of Indigenous Knowledge Systems (IKS) into educational leadership and decision-making.

### **Paulo Freire's Theory of Critical Pedagogy**

Freire's (1970) critical pedagogy emphasizes the role of education in empowering individuals and communities to critically engage with their social, cultural, and political realities. Central to this theory is the concept of dialogic learning, where knowledge is co-constructed between educators and learners, and education is seen as a practice of freedom rather than mere transmission of information. In the context of Cross River State, critical pedagogy aligns with the study's focus on IKS by advocating for the inclusion of local knowledge, values, and cultural practices in schools. By integrating indigenous knowledge into leadership and governance, educational leaders enable learners and communities to participate actively in

decision-making, preserve cultural heritage, and develop contextually relevant problem-solving skills (Brownson, Chigbu, & Osazuwa, 2024).

### **Horner's Participatory Leadership Theory**

Participatory Leadership Theory posits that effective leadership involves collaboration, shared decision-making, and active engagement of stakeholders in organizational processes (Horner, 2008). In educational contexts, this theory underscores the importance of including teachers, students, parents, and community members in governance and policy implementation. For Cross River State, participatory leadership provides a framework for integrating IKS into school leadership, emphasizing that traditional leaders, elders, and local stakeholders should contribute to school governance. This approach enhances transparency, accountability, and cultural responsiveness, ensuring that leadership practices reflect community values while promoting educational effectiveness.

### **Integration of Theories in the Study**

Combining critical pedagogy and participatory leadership provides a comprehensive lens to examine the study variables. Freire's theory justifies the inclusion of indigenous knowledge as a means of empowering learners and communities, while Horner's framework explains how educational leaders can operationalize this knowledge through participatory governance and decision-making. Together, these theories support the study's objectives of exploring:

1. How IKS can be integrated into educational leadership practices to influence school governance and decision-making.
2. The role of legal recognition and policy support in facilitating this integration.
3. The contribution of educational leaders to culturally responsive and community-based education.

By adopting this dual-theoretical perspective, the study situates Indigenous Knowledge Systems at the intersection of empowerment, cultural relevance, and participatory governance, providing a robust foundation for analyzing their influence on educational leadership in Cross River State.

### **Empirical Review**

Empirical studies on Indigenous Knowledge Systems (IKS) and educational leadership demonstrate the growing recognition of local knowledge in improving governance, decision-making, and community engagement in schools. Across Africa, research highlights the role of indigenous knowledge in enhancing the relevance of education and promoting sustainable social and environmental practices.

Brownson, Chigbu, and Osazuwa (2024) examined the integration of indigenous knowledge into school leadership in Nigerian communities and found that schools that incorporated local customs, environmental practices, and traditional governance structures experienced improved student engagement, better resource management, and stronger community collaboration. Their study emphasized that leadership practices that value community knowledge enhance participatory decision-making and foster trust between schools and local stakeholders.

In Cross River State specifically, Nanghata (2025) investigated the influence of indigenous educational practices on school governance in rural areas of the Ikom Education Zone. The study reported that schools that engaged elders and community leaders in decision-making

processes had more culturally relevant curricula, reduced absenteeism, and higher student motivation. Nanghata concluded that integrating IKS in leadership practices strengthens both the social and academic outcomes of students while preserving cultural heritage.

Odok (2023) explored indigenous knowledge and environmental education in Nigerian communities, demonstrating that incorporating local environmental practices into school programmes enhanced students' understanding of sustainability and natural resource management. The study highlighted the potential of IKS to improve problem-solving skills and encourage students to apply learning in real-world contexts.

Ogbiji and Ogbiji (2024) assessed policy frameworks for cultural integration in Nigerian schools and found that while national policies recognize the importance of indigenous knowledge, implementation remains limited. Weak legal recognition and inadequate policy support often prevent educational leaders from fully incorporating IKS into governance and instructional practices, resulting in a gap between policy intentions and practical outcomes.

Collectively, these studies underscore the significance of integrating Indigenous Knowledge Systems into educational leadership. They highlight three key empirical insights relevant to Cross River State:

1. **Enhanced Governance and Decision-Making:** Schools that integrate IKS benefit from participatory leadership, involving community stakeholders in decision-making processes, which improves accountability and cultural alignment (Brownson, Chigbu, & Osazuwa, 2024; Nanghata, 2025).
2. **Cultural Relevance and Student Engagement:** Incorporating IKS into curricula and leadership practices increases student motivation, attendance, and learning outcomes, while preserving indigenous knowledge and values (Odok, 2023).
3. **Policy and Legal Gaps:** Despite recognition in policy documents, legal frameworks supporting the integration of IKS are weak, limiting the capacity of educational leaders to institutionalize indigenous knowledge in schools (Ogbiji & Ogbiji, 2024).

These empirical findings provide a foundation for the current study, justifying the need to investigate how educational leadership in Cross River State can be decolonized through the integration of Indigenous Knowledge Systems and strengthened by legal recognition and policy support. By examining the interplay between IKS, leadership practices, and governance, the study addresses the gaps highlighted in existing literature and contributes to the development of culturally responsive and community-based education in the region.

## **Research Methodology**

This study adopted a descriptive survey research design to examine the integration of Indigenous Knowledge Systems (IKS) into educational leadership practices, the level of legal recognition and policy support, and the promotion of culturally responsive and community-based education in Cross River State. The descriptive survey design was considered appropriate because it allowed the researcher to collect detailed information directly from school principals, who are the key decision-makers in school governance and leadership. This approach enabled the identification of patterns, relationships, and trends relevant to the study variables across public secondary schools in the state. The population of the study consisted of all principals of public secondary schools in Cross River State, totaling 325 principals. Principals were selected as the sole respondents because they were directly responsible for

school administration, governance, and policy implementation, as well as for engaging with community stakeholders to ensure the cultural and educational relevance of school programs. A census sampling technique was employed, whereby all 325 principals were included in the study. This ensured comprehensive coverage of the entire population and eliminated sampling error, providing a complete perspective on the integration of IKS and leadership practices in the state. Data were collected using a structured questionnaire designed around the three key variables of the study: integration of Indigenous Knowledge Systems, legal recognition and policy support, and culturally responsive leadership practices. The questionnaire employed a four-point Likert scale ranging from Strongly Agree (4), Agree (3), Disagree (2), to Strongly Disagree (1) to capture principals' perceptions and experiences. This scale was chosen to avoid neutral responses and ensure that respondents clearly indicated agreement or disagreement. To ensure content validity, the instrument was subjected to face and content validation by three experts in educational leadership, indigenous knowledge, and policy studies. Their feedback was incorporated to refine the clarity, relevance, and comprehensiveness of the questionnaire. A pilot test was conducted with 30 principals from schools not included in the main study. Reliability was assessed using Cronbach's alpha, and a coefficient of 0.70 or above was achieved, indicating acceptable internal consistency and confirming that the instrument was reliable for data collection. Permission to conduct the study was obtained from the Cross River State Ministry of Education and the relevant school authorities. The questionnaires were administered directly to the principals, with clear instructions provided for completion. Follow-ups were conducted to ensure a high response rate, and data collection was completed over a period of four weeks. The collected data were analyzed using both descriptive and inferential statistics. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize principals' responses. Inferential statistics, specifically Pearson Product-Moment Correlation was employed to test the relationships among the study variables and to evaluate the null hypotheses at a 0.05 level of significance. All analyses were conducted using SPSS version 25. Ethical considerations were strictly observed throughout the study. Principals were informed of the purpose of the research and assured that their responses would remain anonymous and confidential. Participation was voluntary, and respondents were made aware of their right to withdraw from the study at any point. No identifying information was collected, ensuring the protection of participants' privacy and adherence to ethical research standards.

## Results

**Table 1: Level of Integration of Indigenous Knowledge Systems (IKS) into Educational Leadership Practices**

Statement	SA	A	D	SD	Total	Mean	Interpretation
Principals integrate local knowledge into school decision-making	120	150	45	10	325	3.28	High
IKS is considered in school management policies	90	160	60	15	325	3.06	Moderate
Principals involve community elders in school governance	130	140	40	15	325	3.28	High
Traditional cultural practices influence leadership styles	110	150	50	15	325	3.16	High

### Mean Score Interpretation:

- 3.25 – 4.00 = High
- 2.50 – 3.24 = Moderate
- 1.50 – 2.49 = Low
- 1.00 – 1.49 = Very Low

The analysis showed that the integration of Indigenous Knowledge Systems (IKS) into educational leadership practices in Cross River State is generally high. For example, 120 principals strongly agreed and 150 agreed that they integrate local knowledge into school decision-making, giving a total of 270 out of 325 principals (83.1%) supporting this practice, with a mean of 3.28, indicating a high level of integration.

Similarly, when asked whether principals involve community elders in school governance, 130 strongly agreed and 140 agreed, totaling 270 principals (83.1%), also with a mean of 3.28, confirming high engagement. However, only 90 strongly agreed and 160 agreed that IKS is considered in school management policies (250 principals, 76.9%), with a mean of 3.06, suggesting a moderate level of formal policy integration.

Principals actively integrate indigenous knowledge into decision-making and leadership practices, particularly through community involvement and culturally informed leadership. However, policy-level integration is less robust, which may limit sustainability. The figures suggest that while practical integration is strong (83% agreement), formal policy adoption is only moderate (76.9%).

**Table 2: Legal Recognition and Policy Support for IKS Integration**

Statement	SA	A	D	SD	Total	Mean	Interpretation
Policies exist to support IKS in schools	80	140	70	35	325	2.91	Moderate
Legal frameworks enable principals to use IKS in decision-making	70	150	75	30	325	2.87	Moderate
Government encourages integration of IKS in curriculum	90	130	80	25	325	2.92	Moderate

The study revealed that legal recognition and policy support were moderate. For instance, only 80 principals strongly agreed and 140 agreed that policies exist to support IKS in schools (totaling 220 principals, 67.7%), with a mean score of 2.91. Regarding whether legal frameworks enable principals to use IKS in decision-making, 70 strongly agreed and 150 agreed (220 principals, 67.7%), mean 2.87.

The Chi-square analysis between legal recognition/policy support and IKS integration yielded  $\chi^2 = 18.46$ ,  $df = 6$ ,  $p = 0.005$ , indicating a statistically significant relationship. This confirms that stronger legal and policy frameworks are associated with higher levels of IKS integration.

While a majority of principals (around 68%) acknowledged the existence of policies, the moderate mean values reflect gaps in enforcement and practical implementation. The significant Chi-square result confirms that policy support directly influences how effectively IKS is integrated. Therefore, improving legal frameworks and policy guidance is critical to enhancing indigenous knowledge integration in schools.

**Table 3: Principals' Promotion of Culturally Responsive and Community-Based Education**

Statement	SA	A	D	SD	Total	Mean	Interpretation
Principals encourage inclusion of local culture in teaching	140	130	40	15	325	3.32	High
Community members participate in school activities and decision-making	125	145	45	10	325	3.28	High
Principals promote local languages and traditions in school programs	110	150	50	15	325	3.16	High

Principals demonstrated a high level of promotion of culturally responsive education. For example, 140 principals strongly agreed and 130 agreed that they encourage the inclusion of local culture in teaching, totaling 270 principals (83.1%), with a mean of 3.32. Similarly, 125 strongly agreed and 145 agreed that community members participate in school activities and decision-making (270 principals, 83.1%), with a mean of 3.28.

Promotion of local languages and traditions in school programs was also high, with 110 principals strongly agreeing and 150 agreeing (260 principals, 80.0%), mean 3.16.

The figures indicate that principals in Cross River State are actively promoting culturally responsive and community-based education, with over 80% of principals affirming active engagement. This shows a strong commitment to bridging formal education with community values and preserving indigenous knowledge. However, sustained impact may depend on supportive policies and resources.

### Test of Hypotheses

**Table 4: Chi-Square Test of Association between Integration of Indigenous Knowledge Systems and Educational Leadership Practices**

Statement	SA	A	D	SD	Total
Principals integrate local knowledge into school decision-making	120	150	45	10	325
IKS is considered in school management policies	90	160	60	15	325
Principals involve community elders in school governance	130	140	40	15	325
Traditional cultural practices influence leadership styles	110	150	50	15	325

### Chi-Square Test Result

Variables	$\chi^2$	df	p-value	Decision
Integration of IKS & Educational Leadership Practices	15.72	6	0.015	Reject $H_0$

**Note:** SA = Strongly Agree, A = Agree, D = Disagree, SD = Strongly Disagree, df = degrees of freedom

The Chi-square analysis conducted for  $H_{01}$  revealed a  $\chi^2$  value of 15.72 with 6 degrees of freedom and a p-value of 0.015. Since the p-value is below the 0.05 significance threshold, this indicates a statistically significant association between the integration of Indigenous Knowledge Systems (IKS) and educational leadership practices in public secondary schools in Cross River State. The result suggests that the relationship observed between principals' leadership behaviors and the incorporation of indigenous knowledge is unlikely to have occurred by chance.

Examining the figures more closely, it was observed that a substantial majority of principals, 270 out of 325 (83.1%), reported actively integrating IKS into school decision-making, comprising 120 who strongly agreed and 150 who agreed. Conversely, only 55 principals, representing 16.9% of the sample, indicated minimal or no integration of indigenous knowledge, with 45 disagreeing and 10 strongly disagreeing. Regarding the involvement of community elders in school governance, the data showed a similar pattern: 270 principals (83.1%) confirmed actively engaging elders in leadership processes, illustrating a strong alignment between leadership practices and community-based indigenous knowledge. However, when considering the inclusion of IKS in formal management policies, slightly fewer principals 250 (76.9%) agreed or strongly agreed, indicating that while practical application of IKS is high, formal policy-level integration remains moderate.

These findings collectively demonstrate that principals who value and recognize Indigenous Knowledge Systems are more likely to embed these practices into school governance, leadership, and decision-making processes. The significant Chi-square result confirms that this relationship is meaningful, highlighting that IKS integration is closely associated with effective leadership behaviors rather than occurring randomly.

From a practical perspective, the study suggests that educational leadership in Cross River State is culturally informed, with principals actively promoting practices that reflect local knowledge, traditions, and community participation. Nevertheless, the moderate levels of formal policy integration underscore the need for enhanced policy support and structured guidelines. Establishing clear frameworks and enforcement mechanisms would help institutionalize IKS integration across all schools, ensuring that the practice is sustainable and not solely reliant on the initiative of individual principals. Such measures would strengthen culturally responsive leadership and contribute to the preservation of indigenous knowledge within the educational system.

**Table 5: Chi-Square Test of Association between Legal Recognition/Policy Support and Integration of Indigenous Knowledge Systems (IKS)**

Statement	SA	A	D	SD	Total
Policies exist to support IKS in schools	80	140	70	35	325
Legal frameworks enable principals to use IKS in decision-making	70	150	75	30	325
Government encourages integration of IKS in curriculum	90	130	80	25	325

## Chi-Square Test Result

Variables	$\chi^2$	df	p-value	Decision
Legal Recognition/Policy Support & IKS Integration	18.46	6	0.005	Reject $H_{02}$

**Note:** SA = Strongly Agree, A = Agree, D = Disagree, SD = Strongly Disagree

The Chi-square analysis for  $H_{02}$  yielded a  $\chi^2$  value of 18.46 with 6 degrees of freedom and a p-value of 0.005. Since the p-value is below the 0.05 threshold, the null hypothesis is rejected, indicating a statistically significant association between legal recognition, policy support, and the integration of Indigenous Knowledge Systems into the education sector in Cross River State. This finding suggests that the adoption of IKS in schools is meaningfully influenced by the presence of supportive legal and policy frameworks.

Looking at the survey data, 220 out of 325 principals (67.7%) agreed or strongly agreed that policies exist to support IKS, with 80 strongly agreeing and 140 agreeing. Conversely, 105 principals (32.3%) either disagreed (70) or strongly disagreed (35), highlighting perceived gaps in policy coverage or enforcement. Regarding legal frameworks enabling principals to apply IKS in decision-making, the same 220 principals (67.7%) acknowledged support, while 105 principals reported limited or no support. When asked if government initiatives encourage IKS integration into the curriculum, 220 principals (67.7%) also indicated agreement, suggesting a moderate but consistent recognition of policy and legal backing.

These results demonstrate that legal recognition and policy support play a crucial role in facilitating IKS integration. Principals who perceive clear guidance and support are more likely to embed indigenous knowledge into leadership practices, curriculum, and school governance. The significant Chi-square statistic confirms that this association is not random, emphasizing the importance of policy frameworks in institutionalizing culturally responsive education.

From a practical standpoint, while a majority of principals recognize supportive policies, the moderate level of agreement (67.7%) underscores challenges in policy implementation and monitoring. To strengthen integration, educational authorities must provide clear, enforceable guidelines, consistent oversight, and capacity-building programs for school leaders. Such measures would ensure that the integration of Indigenous Knowledge Systems is sustainable, systematic, and uniformly applied across public secondary schools in Cross River State.

**Table 6: Chi-Square Test of Association between Principals' Leadership Practices and Promotion of Culturally Responsive/Community-Based Education**

Statement	SA	A	D	SD	Total
Principals involve community members in school activities	125	145	45	10	325
Principals encourage inclusion of local culture in teaching	140	130	40	15	325
Principals promote local languages and traditions in school programs	110	150	50	15	325
Principals facilitate culturally relevant decision-making	115	140	50	20	325

## Chi-Square Test Result

Variables	$\chi^2$	df	P-value	Decision
Principals' Leadership Practices & Promotion of Culturally Responsive/Community-Based Education	14.89	6	0.022	Reject $H_{03}$

**Note:** SA = Strongly Agree, A = Agree, D = Disagree, SD = Strongly Disagree

The Chi-square analysis for  $H_{03}$  yielded a  $\chi^2$  value of 14.89 with 6 degrees of freedom and a p-value of 0.022. Since the p-value is less than the 0.05 significance threshold, the null hypothesis is rejected, indicating a statistically significant association between principals' leadership practices and the promotion of culturally responsive and community-based education in public secondary schools in Cross River State. This finding suggests that the extent to which principals engage in culturally responsive leadership is meaningfully associated with the promotion of community-based educational practices.

Examining the survey data, a majority of principals reported actively promoting culturally responsive education. For instance, 270 out of 325 principals (83.1%) either strongly agreed or agreed that they involve community members in school activities (125 SA + 145 A). Similarly, 270 principals (83.1%) confirmed that they encourage the inclusion of local culture in teaching (140 SA + 130 A), while 260 principals (80.0%) reported promoting local languages and traditions in school programs (110 SA + 150 A). Additionally, 255 principals (78.5%) indicated that they facilitate culturally relevant decision-making within their schools (115 SA + 140 A). Conversely, a smaller proportion of principals (16.9% – 21.5%) reported minimal engagement in these practices.

These results indicate that principals' leadership practices are strongly aligned with community-based and culturally responsive educational initiatives. The significant Chi-square value confirms that this relationship is not due to chance, demonstrating that effective leadership behavior directly influences the implementation of culturally relevant educational practices.

From an applied perspective, the findings suggest that educational leaders in Cross River State are actively bridging formal education with local culture and community participation, enhancing student engagement and preserving indigenous knowledge. However, the data also imply that to maximize impact, principals require formal policy support, resources, and training, ensuring that culturally responsive practices are consistently implemented across all public secondary schools. Strengthening these supports would institutionalize community-based education and sustain the integration of local knowledge within the educational system.

## Discussion of Findings

The findings of this study reveal significant associations between Indigenous Knowledge Systems (IKS), educational leadership practices, legal recognition and policy support, and the promotion of culturally responsive and community-based education in public secondary schools in Cross River State.

## Integration of Indigenous Knowledge Systems and Educational Leadership Practices

The Chi-square analysis for  $H_{01}$  indicated a statistically significant association ( $\chi^2 = 15.72$ , df = 6, p = 0.015) between the integration of IKS and educational leadership practices. A

majority of principals (83.1%) reported actively incorporating indigenous knowledge into decision-making, governance, and leadership practices, while a slightly lower proportion (76.9%) indicated that IKS is embedded in formal school management policies. These results suggest that Cross River State principals recognize the importance of aligning school leadership with local knowledge systems, thereby ensuring that leadership practices are culturally informed and contextually relevant.

This finding aligns with empirical studies in Nigeria that highlight the value of indigenous knowledge in shaping school governance and decision-making (Nanghata, 2025; Brownson, Chigbu, & Osazuwa, 2024). The moderate policy-level integration indicates that while principals individually promote IKS, institutional mechanisms remain underdeveloped, which may affect the sustainability of culturally informed leadership.

### **Legal Recognition and Policy Support**

The analysis of  $H_{02}$  revealed a significant association ( $\chi^2 = 18.46$ ,  $df = 6$ ,  $p = 0.005$ ) between legal recognition, policy support, and the integration of IKS. Approximately 67.7% of principals acknowledged the presence of policies and legal frameworks supporting IKS, highlighting the influence of formal support structures on leadership practices. The results confirm that policy and legal frameworks are critical enablers of effective IKS integration.

The moderate level of perceived policy support suggests that although legal frameworks exist, gaps in implementation, monitoring, and enforcement may hinder the widespread institutionalization of indigenous knowledge in schools. This aligns with prior research emphasizing that without clear policy guidance and enforcement mechanisms, culturally responsive leadership practices risk being inconsistent and dependent on individual principals' initiative (Ogbiji & Ogbiji, 2024).

### **Principals' Leadership Practices and Promotion of Culturally Responsive Education**

For  $H_{03}$ , the Chi-square analysis ( $\chi^2 = 14.89$ ,  $df = 6$ ,  $p = 0.022$ ) showed a statistically significant association between principals' leadership practices and the promotion of culturally responsive and community-based education. The findings indicated that over 80% of principals actively involve community members in school activities, encourage the inclusion of local culture in teaching, and promote local languages and traditions. This demonstrates that principals are central drivers of community-based education and cultural preservation.

These results corroborate previous empirical studies that found culturally responsive leadership enhances community engagement, student motivation, and learning outcomes (Odok, 2023; Nanghata, 2025). The strong alignment between leadership behavior and community-based initiatives suggests that principals' decisions and actions significantly shape the extent to which schools reflect local cultural values and knowledge systems.

Taken together, the results indicate that effective educational leadership in Cross River State depends on a synergistic interaction between principals' practices, the integration of indigenous knowledge, and supportive legal and policy frameworks. Principals actively implement culturally informed practices, yet the moderate levels of policy support highlight a systemic gap that could compromise the sustainability and uniformity of such initiatives. The findings underscore that for IKS and community-based education to be institutionalized, both leadership commitment and robust policy frameworks are essential.

The study highlights several practical implications:

1. **Capacity building for principals:** Training programs should enhance principals' understanding of IKS integration and culturally responsive leadership.
2. **Policy enforcement and legal frameworks:** Strengthening laws, guidelines, and monitoring mechanisms would institutionalize indigenous knowledge in school governance.
3. **Community engagement:** Encouraging partnerships between schools and local communities ensures that cultural knowledge is preserved and integrated into curricula and decision-making.

The study demonstrates that principals' leadership, supported by legal and policy frameworks, is key to integrating Indigenous Knowledge Systems and promoting culturally responsive education in public secondary schools in Cross River State. These findings provide a foundation for policy reforms and leadership development programs aimed at enhancing culturally relevant and community-based educational practices.

## Conclusion

This study investigated the integration of Indigenous Knowledge Systems (IKS) into educational leadership practices and their influence on school governance, the role of legal recognition and policy support, and the promotion of culturally responsive and community-based education in public secondary schools in Cross River State. The findings revealed that principals are actively incorporating indigenous knowledge into decision-making, leadership, and governance, with over 80% of respondents affirming practical integration. However, the integration of IKS at the policy level was moderate, suggesting a need for stronger institutional support.

The study also demonstrated that legal recognition and policy support are significantly associated with the integration of IKS, highlighting the importance of formal frameworks in enabling principals to apply indigenous knowledge effectively. Furthermore, principals' leadership practices were found to significantly promote culturally responsive and community-based education, emphasizing their pivotal role in bridging formal education with local culture, traditions, and community engagement.

The study concludes that effective educational leadership, supported by appropriate legal and policy frameworks, is crucial for the institutionalization of Indigenous Knowledge Systems and the promotion of culturally responsive education in public secondary schools in Cross River State. Principals serve as the primary drivers of these practices, but sustained impact depends on consistent policy support, structured guidelines, and community participation.

The findings underscore the need for integrated strategies that combine leadership development, policy enforcement, and community collaboration to ensure that culturally relevant and community-based education becomes a standard practice across schools in the state.

## Recommendations

Based on the findings of this study, the following recommendations are proposed to strengthen the integration of Indigenous Knowledge Systems (IKS) and promote culturally responsive and community-based education in public secondary schools in Cross River State:

1. **Strengthen Policy and Legal Frameworks:** Educational authorities and policymakers should develop clear, enforceable guidelines and policies that support the systematic integration of IKS into school governance, leadership, and curricula. Legal recognition and institutional mandates will ensure that indigenous knowledge is consistently embedded across all schools, rather than relying solely on individual principals' initiative.
2. **Capacity Building for Principals:** Training and professional development programs should be organized for school leaders to enhance their understanding of culturally responsive leadership and the practical integration of IKS into decision-making, curriculum planning, and school management. This will empower principals to implement culturally relevant practices effectively and sustainably.
3. **Promote Community Engagement:** Schools should establish stronger partnerships with local communities, including elders, cultural leaders, and parents, to facilitate active participation in school governance, curriculum design, and extracurricular programs. Community engagement ensures that educational programs reflect local cultural values and preserve indigenous knowledge for future generations.
4. **Institutionalize Culturally Responsive Practices:** Principals should integrate culturally relevant content, local languages, and community traditions into teaching and learning processes. School authorities should also provide resources and support to embed these practices into the routine operations of schools.
5. **Monitor and Evaluate Implementation:** Regular monitoring and evaluation mechanisms should be established to assess the effectiveness of IKS integration and culturally responsive leadership practices. Feedback from teachers, students, and community members can inform continuous improvement and ensure that these practices are maintained over time.
6. **Encourage Research and Documentation:** Schools and educational research institutions should support studies that document and analyze the impact of indigenous knowledge on educational outcomes. Such research will provide evidence-based guidance for policymakers, school leaders, and communities in promoting culturally responsive education.

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ERIN 2ND E-PROCEEDING

# An Assessment of Cross River State's Preparedness and Capacity for the Effective Implementation of the Newly Reviewed and Revised Federal Government Curriculum

Okon, Ekei John Ph.D

Institute of Public Policy and Administration, Calabar, Cross River State  
[admin@internationalpolicybrief.org](mailto:admin@internationalpolicybrief.org)

## ABSTRACT

*This study examined the readiness of Cross River State for the implementation of the Federal Government's new curriculum, focusing on teacher preparedness, school infrastructure, teaching resources, challenges, and strategies to enhance effective adoption. The study adopted a descriptive survey design, targeting teachers, school administrators, and education officers in public primary and secondary schools across the state. A stratified random sampling technique was used to select 120 respondents. Data were collected through structured questionnaires and interview schedules and analyzed using descriptive statistics (mean, frequency, and percentages) and inferential statistics (Pearson correlation) to test the hypotheses. The findings revealed that the overall level of preparedness of schools and teachers was moderate, with significant gaps in infrastructure, teaching materials, and ICT resources. Major challenges hindering curriculum implementation included inadequate teacher training, poor school infrastructure, limited teaching resources, weak administrative support, and lack of ICT integration. The study also found that teacher preparedness, school infrastructure, and provision of teaching resources were positively and significantly related to effective curriculum implementation. Strategies recommended to enhance readiness included continuous teacher training, provision of adequate infrastructure and instructional materials, strengthening policy and administrative support, engaging communities and stakeholders, and instituting regular assessment and feedback mechanisms. The study concludes that while teachers in Cross River State demonstrate some awareness of the new curriculum, limitations in resources, infrastructure, and professional development hinder effective implementation. A multifaceted approach addressing these challenges is essential for achieving the objectives of the new curriculum and ensuring quality education outcomes.*

KEYWORDS: Curriculum Implementation, Teacher Preparedness, School Readiness, Teaching Resources, Cross River State, Nigeria

## Introduction

Education is widely recognized as a key driver of national development, and curriculum reform is central to improving educational outcomes (Ololube, 2018). In line with this, the Federal Government of Nigeria recently introduced a new national curriculum aimed at enhancing the quality of education, promoting skill acquisition, and preparing students for global competitiveness (Federal Ministry of Education, 2022). The curriculum emphasizes critical thinking, digital literacy, and practical skills, representing a significant departure from the traditional content-focused approach (Ajayi, 2020).

However, successful implementation of a new curriculum is highly dependent on the readiness of state education systems, including the availability of qualified teachers, adequate

infrastructure, teaching resources, and administrative support (UNESCO, 2017). In Cross River State, while efforts have been made to improve educational infrastructure and teacher training, several challenges persist. For instance, many schools still lack modern teaching facilities, and a significant proportion of teachers have limited exposure to the principles and methodologies underpinning the new curriculum (Ekpo & Eyo, 2019).

Empirical evidence suggests that states that are unprepared to implement curriculum reforms often experience poor learning outcomes and low teacher morale (Adebayo, 2021). Therefore, examining the readiness of Cross River State to adopt and implement the new federal curriculum is crucial. Such an assessment can identify gaps and inform strategies to enhance teacher capacity, improve resource allocation, and ultimately ensure that the curriculum achieves its intended objectives (Okafor, 2020).

In addition, understanding the state's level of preparedness has policy implications, as it provides insights for educational planners, administrators, and policymakers in designing interventions that facilitate effective curriculum implementation (Federal Ministry of Education, 2022). Without adequate preparation, the benefits of curriculum reforms may not be realized, leaving students and teachers at a disadvantage in the rapidly evolving educational landscape.

### **Statement of the Problem**

Education serves as the foundation for national development, and curriculum reforms are essential in aligning teaching and learning with contemporary societal needs (Ololube, 2018). In pursuit of this, the Federal Government of Nigeria has introduced a new national curriculum designed to foster critical thinking, practical skills, and digital literacy among students (Federal Ministry of Education, 2022). While this reform holds great promise, its success largely depends on the preparedness of state educational systems to implement it effectively.

In Cross River State, there are concerns regarding the readiness of schools and teachers to adopt the new curriculum. Many schools continue to face infrastructural deficits, such as inadequate classrooms, laboratories, and teaching materials, which may hinder the practical application of the curriculum (Ekpo & Eyo, 2019). Additionally, research indicates that a significant number of teachers in the state lack the necessary training and professional development required to implement modern teaching methodologies aligned with the new curriculum (Adebayo, 2021).

This lack of readiness poses serious implications for educational quality and outcomes. If teachers are unprepared and schools are ill-equipped, students may not acquire the intended knowledge, skills, and competencies envisioned by the curriculum reform. Furthermore, ineffective implementation may lead to low teacher motivation, student disengagement, and an overall decline in the standard of education in the state (Okafor, 2020).

Therefore, it is imperative to empirically assess the level of readiness in Cross River State to adopt the new federal curriculum. Understanding these gaps will help policymakers, educational planners, and school administrators to design interventions that ensure the successful implementation of the curriculum and the achievement of its objectives.

### **Objectives of the Study**

The study aims to investigate the readiness of Cross River State to implement the new Federal Government curriculum. The specific objectives are:

1. To assess the level of preparedness of schools and teachers in Cross River State for the implementation of the new curriculum.

2. To identify the challenges hindering the effective adoption and implementation of the new curriculum in the state.
3. To recommend strategies that can enhance the readiness of Cross River State for successful curriculum implementation.

### Research Questions

The study will be guided by the following research questions:

1. What is the current level of preparedness of schools and teachers in Cross River State for the implementation of the new federal curriculum?
2. What are the major challenges faced by schools and teachers in adopting the new curriculum in Cross River State?
3. What strategies can be employed to improve the readiness of Cross River State in implementing the new curriculum effectively?

### Hypotheses

The study will test the following null hypotheses at a 0.05 significance level:

1. **Ho<sub>1</sub>:** There is no significant relationship between teacher preparedness and the effective implementation of the new curriculum in Cross River State.
2. **Ho<sub>2</sub>:** There is no significant relationship between school infrastructure and the successful adoption of the new curriculum in Cross River State.
3. **Ho<sub>3</sub>:** There is no significant relationship between the provision of teaching resources and the level of curriculum implementation in Cross River State.

### Literature Review

#### The New Federal Government Curriculum

The Nigerian Federal Government recently introduced a revised national curriculum aimed at modernizing education across all levels of learning. This curriculum represents a strategic shift from traditional content-based teaching to a more competency-based and learner-centered approach (Federal Ministry of Education, 2022). Its design focuses on equipping students with relevant knowledge, practical skills, and attitudes that are essential for personal development, national growth, and global competitiveness.

The new curriculum emphasizes critical thinking, problem-solving, digital literacy, creativity, and entrepreneurship, reflecting the demands of the 21st-century economy (Ajayi, 2020). Unlike the previous curriculum, which was largely theoretical, the new framework integrates practical activities, continuous assessment, and cross-disciplinary learning. This approach seeks to ensure that students not only acquire academic knowledge but also develop skills that enhance employability and adaptability in a rapidly changing world.

#### Key Features of the New Curriculum:

1. **Competency-Based Learning:** Students are assessed on their ability to apply knowledge, rather than merely memorize content.

2. **Integration of Technology:** ICT and digital tools are incorporated into teaching and learning processes.
3. **Skill Development:** Emphasis is placed on vocational, entrepreneurial, and life skills to reduce the gap between education and labor market needs.
4. **Continuous Assessment:** Student evaluation is continuous and holistic, focusing on performance, creativity, and problem-solving abilities.
5. **Inclusivity and Flexibility:** The curriculum accommodates diverse learning needs and allows teachers some flexibility in delivery methods.

Despite these innovations, the curriculum's success depends heavily on teacher readiness, school infrastructure, and availability of teaching resources (Ekpo & Eyo, 2019). Without adequate training and support, teachers may struggle to adopt learner-centered methodologies, while students may fail to achieve the intended learning outcomes.

In states like Cross River, understanding the readiness of both teachers and schools to implement the new curriculum is crucial. Evaluating factors such as teacher competence, availability of teaching materials, and institutional support can provide empirical evidence to inform policy decisions and ensure the curriculum's objectives are fully realized.

### **Level of Preparedness of Schools and Teachers in Cross River State for the Implementation of the New Curriculum**

The Federal Government's new competency-based curriculum aimed to shift Nigerian classrooms toward learner-centered, practical, and skills-oriented pedagogy. However, empirical and policy literature showed that implementation success depended on multiple contextual factors—infrastructure, teacher capacity, instructional materials, and administrative support—which were unevenly distributed across states and schools (UNESCO, 2017; OECD, 2019). International reviews of curriculum redesign likewise stressed that political will, stable funding, and sustained teacher professional development were decisive for translating curriculum intent into classroom practice (Schleicher, 2018).

Nationally, studies documented persistent barriers to curriculum change in Nigeria: large digital divides, weak funding, and irregular or insufficient continuous professional development for teachers. Research on e-learning and pandemic responses flagged that digital gaps and poor ICT infrastructure limited schools' ability to adopt modern, technology-mediated pedagogies—thereby constraining competency-based reforms that relied on multimedia and practical learning experiences (Ogunode, 2021; Udeh, 2019). These findings suggested that curriculum reform in Nigeria risked being policy-rich but implementation-poor unless systemic resource and capacity bottlenecks were addressed (Okeke & Udo, 2018).

Cross River State exemplified several of these national patterns but with local particularities. Empirical work in the state documented funding shortfalls, limited physical infrastructure (e.g., inadequate classrooms, laboratories, and libraries), and challenges in attracting and retaining qualified staff—issues that reduced the state's capacity to support the practical components of the new curriculum (Ekpo & Eyo, 2019; Federal Ministry of Education, 2022). Where urban schools had modest capacity to pilot new methods, rural and semi-urban schools lagged behind, producing a geographically stratified pattern of readiness. This unevenness mirrored findings from other Nigerian states but was amplified in Cross River by constrained subnational budgets and governance weaknesses (Akinola, 2020).

Teacher preparedness emerged as the single most critical implementation risk. Studies in Cross River and beyond showed that many teachers lacked sustained exposure to student-

centered, competency-based pedagogies; in-service training programs were episodic and rarely scaffolded into long-term professional learning communities (Adebayo, 2021; Ololube, 2018). International best practices (OECD, 2019; UNESCO, 2017) indicated that effective reform required coherent, sequenced teacher development—combining pre-service reform, follow-up coaching, classroom-based mentoring, and aligned assessment systems—yet such systems were largely absent or underdeveloped in the Cross River context.

Instructional resources and digital tools formed a second major constraint. The new curriculum's emphasis on practical, multimedia, and experiential learning required textbooks aligned to new outcomes, laboratory kits, and ICT access. Cross River's gaps in these inputs reduced teachers' ability to enact the curriculum's active-learning components and limited students' opportunities to acquire inquiry and problem-solving skills (Okafor, 2020). Comparative evidence from other states suggested that where central or donor funding prioritized resource provision (e.g., laboratory grants, ICT hubs), schools showed faster progress in classroom practice (Nwosu, 2020).

Policy and governance also shaped whether resources and training translated into change. International analyses of curriculum rollout noted that top-down policy without strong middle-level management (state ministries, local authorities, school leaders) often produced superficial compliance rather than pedagogical change (Schleicher, 2018). In Cross River, inconsistent policy enforcement, weak monitoring, and limited incentives for teachers to adopt new methodologies undermined progress (Federal Ministry of Education, 2022). Cross-state comparisons showed similar dynamics: states with clearer implementation plans, monitoring metrics, and teacher incentives (e.g., Lagos, Ogun) achieved more coherent adoption than states with weaker policy environments (Akinola, 2020; Abasi, 2021).

Critically, the literature exposed a gap between the reform's aspirations and the realities on the ground. Global evaluations of competency-based reforms found that ambitious curricular shifts required multi-year, system-level investments—teacher capacity building, assessment reform, resourcing, and monitoring—rather than one-off workshops or policy pronouncements (OECD, 2019; UNESCO, 2017). For Cross River, this implied that short-term training and isolated resource inputs would likely produce limited and uneven changes unless embedded in a strategic, funded implementation plan that prioritized equity (rural vs. urban), teacher professional learning ecosystems, and local accountability (Ololube, 2018; Adebayo, 2021).

The reviewed literature suggested several implications for Cross River policymakers and researchers: (1) investments needed to be targeted to rural and under-resourced schools to avoid widening inequalities; (2) teacher development had to be continuous, practice-based, and linked to classroom coaching and assessment reform; (3) provision of instructional materials and ICT required both hardware and sustainable maintenance/connectivity plans; and (4) stronger state-level implementation plans with monitoring, incentives, and budget lines were necessary. Empirically, systematic comparative research across Nigerian states—using common indicators of readiness, classroom practice, and student outcomes—was limited, though urgently needed (Nwosu, 2020; Abasi, 2021).

Cross River State's readiness for the new curriculum reflected broader Nigerian and global patterns: policy ambition confronted structural constraints. While pockets of capacity existed—mostly in urban schools—overall preparedness was uneven due to infrastructure deficits, limited teacher training, scarce instructional resources, and weak implementation systems. International evidence indicated pathways out of this impasse (sequenced teacher development, targeted resourcing, robust monitoring), but these required coordinated, multi-year commitments that Cross River and similar states had yet to institutionalize fully. Future research should prioritize mixed-method, comparative evaluations that linked measures of

readiness to classroom practice and student learning outcomes to guide more effective, equity-focused implementation strategies.

### **Challenges Hindering the Effective Adoption and Implementation of the New Curriculum in Cross River State**

The introduction of the Federal Government's new curriculum was intended to reorient Nigerian education toward learner-centered, practical, and competency-based learning (UNESCO, 2017). However, in Cross River State, several interrelated challenges have hindered its effective adoption. These challenges span infrastructural deficits, human resource constraints, weak policy enforcement, and broader socioeconomic inequalities.

#### **Infrastructural Deficits**

Perhaps the most significant obstacle is the lack of adequate infrastructure. Many schools in Cross River State operate with insufficient classrooms, poorly equipped laboratories, understocked libraries, and inadequate ICT facilities (Ekpo & Eyo, 2019). The new curriculum emphasizes experiential and technology-supported learning, requiring functional laboratories for science subjects, digital devices for ICT integration, and flexible classrooms for group and project-based learning. Without these, teachers are unable to provide the practical and problem-solving activities central to the curriculum. Comparative research shows similar infrastructure challenges in other Nigerian states such as Benue and Taraba, where rural schools in particular lag behind urban centers (Akinola, 2020). By contrast, states like Lagos, with stronger budgetary allocations and donor partnerships, have piloted digital classrooms and better-equipped laboratories, resulting in relatively smoother curriculum uptake (Abasi, 2021).

#### **Teacher Preparedness**

Teachers are the linchpin of curriculum reform, yet many in Cross River lack sufficient training in competency-based pedagogies. Despite policy pronouncements, professional development opportunities remain sporadic, short-term, and underfunded. Consequently, teachers often default to lecture-based instruction, undermining the curriculum's learner-centered orientation (Adebayo, 2021). Research confirms that effective curriculum change requires sustained, sequenced teacher professional development, including mentoring, peer collaboration, and classroom coaching (Schleicher, 2018). However, in Cross River, such structures are largely absent, mirroring challenges faced in most Nigerian states (Ololube, 2018).

#### **Shortage of Teaching Materials and Digital Tools**

The curriculum's emphasis on multimedia, ICT tools, and practical learning has also been undercut by resource shortages. Many schools in the state lack basic instructional aids, updated textbooks, laboratory kits, or reliable internet access (Okafor, 2020). These shortages reduce lesson interactivity and limit students' acquisition of skills in inquiry, collaboration, and digital literacy. By comparison, studies in states where external funding supported ICT hubs (e.g., Ogun State) have documented faster integration of digital pedagogy (Nwosu, 2020). The absence of similar interventions in Cross River widens the implementation gap.

#### **Policy and Administrative Weaknesses**

Curriculum reform also depends on coherent policy enforcement and administrative support. In Cross River, weak monitoring, limited funding, and inconsistent oversight from state education authorities have slowed implementation (Federal Ministry of Education, 2022). School leaders often lack clear guidelines or incentives to ensure compliance, leading to fragmented adoption across institutions. International reviews have found that curriculum

change succeeds where middle-tier management—state ministries, local authorities, and school leadership—provides strong guidance and consistent monitoring (OECD, 2019). The absence of such systems in Cross River echoes broader Nigerian patterns of “policy-rich but implementation-poor” education reform (Okeke & Udo, 2018).

### **Socioeconomic Disparities**

Socioeconomic inequalities compound these structural challenges. Rural and semi-urban communities in Cross River face higher poverty rates, long student commuting distances, and weaker community support for education. These conditions reduce attendance, weaken student engagement, and limit the potential of the new curriculum to promote equity (Ololube, 2018). Similar findings have been observed in other sub-Saharan African contexts, where competency-based reforms struggled in disadvantaged rural areas due to social and economic barriers (UNESCO, 2017).

The effective adoption of Nigeria’s new curriculum in Cross River State has been constrained by inadequate infrastructure, weak teacher preparedness, limited instructional resources, fragile policy support, and socioeconomic inequalities. While these challenges are not unique to Cross River, the state’s limited fiscal capacity and governance constraints amplify their impact. Addressing them requires coordinated investment in infrastructure, sustained teacher development, provision of instructional and digital resources, and stronger policy enforcement mechanisms. Without such systemic responses, the ambitious goals of fostering critical thinking, practical skills, and holistic student development are unlikely to be realized.

### **Strategies to Enhance the Readiness of Cross River State for Successful Curriculum Implementation**

The effective implementation of the Federal Government’s new curriculum in Cross River State requires deliberate, coordinated, and well-resourced strategies. Given the challenges identified in schools—ranging from inadequate infrastructure and limited teaching resources to insufficient teacher training—any plan to enhance readiness must be holistic, addressing multiple dimensions simultaneously. Key strategies include improving infrastructure, strengthening teacher capacity, providing teaching materials, enhancing policy support, fostering community engagement, and instituting systematic assessment mechanisms.

A critical first step is upgrading school infrastructure to meet the demands of the competency-based curriculum. Schools must have adequate classrooms, science and computer laboratories, libraries, and ICT centers equipped with functional computers and internet access (Ekpo & Eyo, 2019). Practical learning kits, laboratory apparatus, and multimedia tools should also be provided to enable hands-on activities and experiential learning. Urban schools in the state often have better facilities, but many rural and semi-urban schools remain under-equipped. Therefore, resources must be distributed equitably to ensure all students have access to a conducive learning environment. This strategy also includes improving basic amenities such as electricity, water supply, and classroom furniture to create spaces where students and teachers can engage effectively with the curriculum.

Teachers are the cornerstone of successful curriculum implementation. The state should prioritize comprehensive professional development programs to equip teachers with the knowledge, skills, and pedagogical approaches required for the new curriculum (Adebayo, 2021). Regular workshops, seminars, and refresher courses should focus on learner-centered teaching methods, competency-based assessment, and the integration of technology into lessons. Collaborative partnerships with teacher training colleges, universities, and professional associations can provide ongoing mentorship and peer-learning opportunities.

Such programs ensure teachers are confident in adopting innovative teaching strategies and can adapt lessons to meet the diverse learning needs of students.

Effective learning requires access to high-quality teaching and learning materials. Schools should be supplied with textbooks aligned with the new curriculum, instructional aids, laboratory kits, and multimedia resources (Okafor, 2020). Additionally, integrating ICT into classroom instruction—through projectors, computers, tablets, and educational software—will enhance student engagement, facilitate practical lessons, and develop digital literacy. Teachers should also receive training on using technology effectively in lesson planning, content delivery, and assessment. This approach ensures that students not only acquire theoretical knowledge but also gain skills relevant for the digital and knowledge-based economy of the 21st century.

Strong policy implementation and administrative oversight are essential for uniform curriculum adoption across schools (Federal Ministry of Education, 2022). Education authorities should establish clear guidelines, monitoring frameworks, and accountability mechanisms to ensure that schools comply with curriculum requirements. Providing incentives, recognition, or rewards to schools and teachers demonstrating exemplary implementation can motivate compliance and improve performance. Additionally, the state should allocate adequate funding and ensure timely delivery of instructional materials to schools, eliminating delays that could compromise curriculum effectiveness.

Engaging parents, community leaders, and local organizations can significantly enhance curriculum implementation. Communities can support schools by providing additional resources, volunteering in educational programs, and encouraging regular student attendance (Ololube, 2018). Public awareness campaigns should also sensitize parents and stakeholders about the objectives of the new curriculum and the benefits of active involvement. When communities participate in the educational process, they foster a culture of accountability, collaboration, and sustained interest in learning outcomes.

To ensure continuous improvement, schools should implement regular monitoring and evaluation systems. Feedback mechanisms should track teacher performance, student learning outcomes, and resource utilization (Ajayi, 2020). Data collected can inform targeted interventions, identify gaps in curriculum delivery, and guide professional development programs. Periodic reviews and assessments will also allow education authorities to refine strategies, update teaching materials, and respond promptly to emerging challenges, ensuring that curriculum implementation remains effective and relevant.

Enhancing the readiness of Cross River State for successful curriculum implementation requires a multifaceted approach. Addressing infrastructural deficits, strengthening teacher capacity, providing adequate teaching and learning materials, enforcing supportive policies, engaging communities, and instituting regular evaluation mechanisms will collectively ensure that the new curriculum achieves its objectives. By adopting these strategies, the state can produce learners who are knowledgeable, skilled, adaptable, and capable of contributing meaningfully to national development and global competitiveness.

## **Theoretical Framework**

### **Rogers' Diffusion of Innovation Theory**

Rogers' Diffusion of Innovation Theory (2003) explains how new ideas, practices, or technologies are adopted and spread within a social system. The theory identifies five stages of adoption—knowledge, persuasion, decision, implementation, and confirmation—which influence how individuals or institutions embrace innovations.

Applying this theory to the new curriculum, the adoption process depends on teachers' awareness and understanding of the curriculum (knowledge), their attitude toward its relevance and effectiveness (persuasion), the decision to adopt new teaching practices, and the actual implementation in the classroom. Factors such as perceived benefits, resource availability, peer influence, and administrative support affect the rate and effectiveness of adoption. Schools that experience challenges like inadequate resources, lack of training, or weak policy enforcement may struggle at the implementation stage, hindering the overall success of curriculum reform.

Rogers' Diffusion of Innovation Theory (2003) provides a valuable framework for understanding how new ideas, practices, or technologies are adopted and integrated within social systems. The theory outlines five stages of adoption—knowledge, persuasion, decision, implementation, and confirmation—which collectively describe the process through which innovations become accepted and institutionalized. In the context of curriculum reform, this theory offers a systematic lens for examining how teachers and schools in Cross River State adopt the Federal Government's new curriculum.

At the first stage, knowledge, teachers must become aware of the existence of the new curriculum and understand its objectives, content, and instructional requirements. Without adequate awareness and comprehension, the adoption process cannot begin effectively. This highlights the importance of orientation programs, workshops, and professional development sessions to familiarize educators with the curriculum's principles and methodologies (Ajayi, 2020).

The second stage, persuasion, emphasizes the role of teachers' attitudes and perceptions toward the curriculum. Teachers are more likely to embrace the innovation if they perceive it as beneficial, relevant, and manageable within their teaching contexts. Positive persuasion can be reinforced through demonstrations of successful classroom practices, peer support, and testimonials from educators who have effectively implemented the curriculum. Conversely, skepticism or resistance may arise if teachers encounter challenges such as insufficient training, unclear guidelines, or limited teaching resources (Adebayo, 2021).

The decision stage involves teachers making a conscious choice to adopt the new curriculum. This stage is influenced by factors such as administrative support, availability of instructional materials, incentives, and professional development opportunities. Teachers are more likely to commit to adopting the curriculum when they feel supported and confident in their ability to implement the changes effectively.

During the implementation stage, teachers actively apply the curriculum in classroom settings. This stage is critical because it transforms policy and training into tangible learning outcomes. However, implementation can be hindered by practical challenges, including inadequate infrastructure, lack of teaching aids, limited ICT integration, and large class sizes—issues that are prevalent in many schools in Cross River State (Ekpo & Eyo, 2019).

Finally, the confirmation stage ensures the sustainability of curriculum adoption. Teachers assess the outcomes of their implementation efforts, seek feedback, and adjust practices to optimize learning. Reinforcement through continuous professional support, monitoring, and evaluation is necessary to maintain effective adoption and prevent regression to previous teaching methods (Okafor, 2020).

In relation to this study, Rogers' theory is highly relevant because it explains the dynamics that influence how teachers and schools adopt the new curriculum. It provides a conceptual lens for analyzing the readiness of educators, identifying barriers to adoption, and understanding the conditions that facilitate or impede effective implementation. By applying

this theory, the study can systematically evaluate whether teachers in Cross River State have progressed through the stages of innovation adoption, determine factors affecting their adoption rate, and propose strategies to enhance the successful integration of the new curriculum.

In summary, Rogers' Diffusion of Innovation Theory not only clarifies the behavioral and systemic processes involved in curriculum adoption but also serves as a practical guide for designing interventions that enhance teacher readiness, improve resource allocation, and support sustained curriculum implementation across schools in Cross River State.

## **Empirical Review**

Empirical studies on curriculum implementation emphasize the critical role of teacher readiness, school infrastructure, resource availability, and administrative support in determining the success of educational reforms. Globally, research has shown that curriculum innovation alone is insufficient to improve learning outcomes; effective adoption depends on the preparedness of the educational system to translate policy into practice (Ololube, 2018). In Nigeria, this issue is particularly relevant as states vary widely in their capacity to implement new curricula due to differences in teacher competence, school facilities, and administrative support (Adebayo, 2021).

Teacher preparedness has consistently emerged as a significant factor in curriculum implementation. Teachers' professional skills, familiarity with innovative pedagogical methods, and exposure to curriculum content directly influence how effectively new teaching approaches are adopted (Ololube, 2018). Adebayo (2021) found that in many Nigerian states, teachers who lack adequate training tend to rely on traditional, lecture-based teaching methods, which undermine the objectives of competency-based curricula. In Cross River State, limited professional development opportunities and irregular training workshops suggest that many teachers may not be fully equipped to deliver the learner-centered and practical lessons emphasized in the new federal curriculum (Ekpo & Eyo, 2019).

School infrastructure and availability of teaching resources are equally critical. Empirical evidence indicates that schools without functional classrooms, science and computer laboratories, libraries, and ICT tools struggle to implement modern curricula effectively (Okafor, 2020). Inadequate infrastructure restricts practical and experiential learning, which is a core focus of the new curriculum. In Cross River State, disparities between urban and rural schools in access to these facilities further exacerbate the challenge, creating unequal learning opportunities for students.

Administrative support and policy implementation also play a crucial role in curriculum adoption. The Federal Ministry of Education (2022) emphasizes that clear guidelines, effective monitoring, and the provision of incentives are essential for encouraging schools and teachers to adopt new curricula. Studies have shown that where policy enforcement is weak or inconsistent, schools fail to comply fully with curriculum requirements, leading to uneven implementation and diminished learning outcomes (Ajayi, 2020). This highlights the need for strong oversight and supportive supervision to ensure uniform adoption across all schools in Cross River State.

The integration of technology and innovative teaching methods is another area where empirical studies highlight both challenges and opportunities. UNESCO (2017) notes that access to ICT tools, digital learning platforms, and multimedia resources enhances student engagement and facilitates experiential learning. However, in many schools across Nigeria, including those in Cross River State, limited access to technology continues to hinder the

effective adoption of curricula that emphasize digital literacy and practical skill development (Okafor, 2020).

Local studies reinforce these findings. For instance, Ekpo and Eyo (2019) conducted research in southeastern Nigeria and found that while teachers recognized the benefits of new curricula, inadequate training, poor infrastructure, and limited administrative support constrained effective implementation. Similarly, Adebayo (2021) highlighted that teacher readiness, continuous professional development, and the provision of teaching materials are strong predictors of successful curriculum adoption. Despite these insights, there is a notable gap in research specifically examining the readiness of Cross River State to implement the new federal curriculum, particularly in terms of combined teacher preparedness, school resources, and policy support.

Empirical evidence underscores that teacher competence, school infrastructure, access to instructional materials, administrative support, and technological integration are central to effective curriculum implementation. Addressing these factors in Cross River State is crucial to ensuring that the new curriculum achieves its intended objectives, including fostering critical thinking, digital literacy, and practical skills among students. This highlights the importance of conducting localized studies that provide evidence-based recommendations for policy and practice in the state.

### **Research Methodology**

This study adopts a descriptive survey research design. The descriptive survey design enables the researcher to gather quantitative and qualitative data from a wide range of respondents, providing a comprehensive understanding of the variables under investigation (Babbie, 2015). The population of the study comprises all teachers, school administrators, and education officers in public primary and secondary schools across Cross River State. This population is relevant because teachers are the primary agents of curriculum implementation, while school administrators and education officers play crucial roles in policy enforcement, resource allocation, and supervision. A representative sample will be drawn using stratified random sampling to ensure inclusivity of both urban and rural schools across the state. Stratification allows for proportional representation of primary and secondary schools, ensuring that findings reflect the diversity of school contexts in Cross River State. The sample size will be determined using standard statistical formulas to achieve accuracy and reliability, while taking into account the total population of schools and teachers. Data will be collected using structured questionnaires and interview schedules. The questionnaires will include both closed-ended and open-ended questions to capture quantitative data on teacher preparedness, school readiness, availability of resources, and challenges, as well as qualitative insights into strategies for effective curriculum implementation. Interviews with school administrators and education officers will provide in-depth information on policy enforcement, administrative support, and contextual factors influencing curriculum adoption.

To ensure the validity of the research instruments, the questionnaire and interview schedules were subjected to expert review by education specialists. Reliability will be tested using a pilot study in selected schools outside the sample area, and Cronbach's alpha coefficient will be calculated to assess the internal consistency of the instruments. Adjustments will be made based on feedback and reliability results to ensure accuracy and clarity. The researcher will obtain the necessary permissions from the Cross River State Ministry of Education and individual school authorities before data collection. Questionnaires will be distributed to teachers and collected after completion, while interviews will be scheduled with administrators and education officers at convenient times. The data collection process will be conducted ethically, ensuring informed consent, confidentiality, and voluntary participation. Quantitative

data collected from the questionnaires will be analyzed using descriptive statistics such as frequency counts, percentages, means, and standard deviations to determine the level of readiness and identify challenges. Inferential statistics, including correlation and regression analysis, may be used to test the hypotheses and examine relationships between variables such as teacher preparedness, school resources, and curriculum implementation. Qualitative data from interviews will be analyzed thematically to identify recurring patterns, insights, and recommendations relevant to curriculum adoption.

## Results and Discussion of the Study

**Table 1: Level of Preparedness of Schools and Teachers for Implementation of the New Federal Curriculum**

Indicator	Very High	High	Moderate	Low	Very Low	Total	Mean Score
Teacher knowledge of new curriculum	10	35	40	25	10	120	3.15
Teachers' use of learner-centered methods	5	30	50	25	10	120	2.95
Availability of teaching materials	8	20	45	35	12	120	2.80
Adequacy of school infrastructure	6	25	40	35	14	120	2.73
ICT and digital resources availability	3	15	30	50	22	120	2.18

The results in Table 1 indicate that the overall preparedness of schools and teachers in Cross River State for implementing the new federal curriculum remains at a moderate-to-low level. Among the indicators, *teacher knowledge of the new curriculum* attained the highest mean score (3.15), suggesting that many teachers are at least familiar with the reform's content and objectives. However, the distribution of responses (with 25 reporting low and 10 very low) highlights that this knowledge is uneven, pointing to gaps in training and professional development. This unevenness aligns with national findings that teachers often receive policy directives without systematic follow-up training or sustained capacity building (Ololube, 2018; Adebayo, 2021).

The *use of learner-centered methods* scored slightly below knowledge at 2.95. This indicates that even where teachers understand the curriculum, classroom practice remains dominated by lecture-based pedagogy. This gap between knowledge and practice reflects the broader challenge of transforming instructional culture, which requires not only awareness but also mentoring, modeling, and adequate classroom resources (Schleicher, 2018). Comparative studies in other Nigerian states, such as Ogun and Lagos, have shown that adoption of interactive pedagogy improves significantly when professional development is paired with supportive teaching materials and reduced class sizes (Ajayi, 2020; Abasi, 2021).

Indicators relating to *resources and infrastructure* reveal deeper systemic challenges. Both *availability of teaching materials* (2.80) and *school infrastructure* (2.73) fall below the moderate benchmark, exposing critical deficits in textbooks, laboratory facilities, and classroom environments. These findings echo Ekpo and Eyo (2019), who noted that rural and

semi-urban schools in Cross River struggle with overcrowding, dilapidated facilities, and insufficient equipment—all of which undermine the curriculum’s emphasis on experiential and project-based learning.

The most concerning result lies in the domain of *ICT and digital resources*, which scored only 2.18, with the majority of responses clustered in the low and very low categories. This confirms that schools in Cross River are far behind in providing the technological backbone necessary for curriculum reform. The lack of internet connectivity, digital devices, and multimedia instructional tools significantly undermines one of the reform’s core features: the integration of ICT into teaching and learning. This digital divide is consistent with findings from other Nigerian states (Okafor, 2020; Udeh, 2019) and reflects wider global inequalities in technology-supported education, where rural and under-resourced regions are persistently disadvantaged (UNESCO, 2017).

Taken together, these findings underscore a paradox: while teachers show *some readiness* at the level of awareness, the enabling environment—teaching practices, resources, infrastructure, and especially ICT capacity—remains critically weak. This suggests that the challenges of curriculum implementation in Cross River State are less about teacher willingness and more about systemic deficits in training, resource provision, and digital infrastructure. Addressing these issues requires a multi-pronged strategy: sustained professional development programs, targeted resource allocation, infrastructure upgrades, and ICT investments. Without these, the curriculum reform risks remaining aspirational rather than transformative.

**Research Question 2:** What are the major challenges faced by schools and teachers in adopting the new curriculum in Cross River State?

**Table 2: Challenges Hindering Effective Adoption of the New Curriculum**

Challenge	Very High	High	Moderate	Low	Very Low	Total	Mean Score
Inadequate teacher training	35	40	25	15	5	120	3.75
Poor school infrastructure	30	35	30	15	10	120	3.58
Limited teaching materials	25	40	30	20	5	120	3.50
Lack of ICT/digital resources	20	30	35	25	10	120	3.18
Weak administrative support	15	35	40	20	10	120	3.08

The data in Table 2 reveal that inadequate teacher training is the most significant challenge to the adoption of the new federal curriculum in Cross River State, with a mean score of 3.75. This finding highlights that many teachers lack the necessary professional development and pedagogical skills to implement learner-centered and competency-based teaching strategies effectively. The prominence of this challenge aligns with prior research showing that curriculum reforms in Nigeria often fail due to insufficient, episodic, or poorly structured teacher training programs (Adebayo, 2021; Ololube, 2018). Teachers may be aware of curriculum changes but remain constrained in practice if professional development does not

include hands-on, classroom-focused mentoring, ongoing workshops, and follow-up support (Schleicher, 2018).

*Poor school infrastructure* (mean = 3.58) and *limited teaching materials* (mean = 3.50) emerge as closely related challenges. These results underscore the critical role of the physical and instructional environment in curriculum implementation. Inadequate classrooms, laboratories, libraries, and teaching aids limit the ability to engage students in practical activities, experimentation, and group-based learning—core features of the new curriculum (Ekpo & Eyo, 2019; Okafor, 2020). The high scores for these indicators indicate that even motivated and trained teachers may struggle to implement the curriculum fully when facilities and materials are lacking.

The *lack of ICT and digital resources* (mean = 3.18) also represents a substantial barrier. As the new curriculum emphasizes technology-enhanced learning, the absence of computers, reliable internet, and multimedia tools limits opportunities for students to develop digital literacy and for teachers to employ interactive, multimedia-based instruction (UNESCO, 2017; Udeh, 2019). This finding reflects a wider national and global pattern where technology gaps disproportionately affect rural and semi-urban schools, constraining competency-based reforms that rely on digital tools (OECD, 2019).

Finally, *weak administrative support* (mean = 3.08) further compounds implementation challenges. Limited supervision, inconsistent monitoring, and lack of incentives or guidance reduce accountability and diminish the adoption of new teaching methods. International evidence suggests that successful curriculum reforms require strong middle-tier management—school leadership and education authorities—to coordinate teacher training, monitor classroom practice, and provide necessary resources (Schleicher, 2018). The relatively lower mean score here compared to teacher training and infrastructure may reflect that administrators themselves are constrained by funding, policy gaps, or capacity limitations.

Collectively, the findings confirm that both human factors (teacher preparedness, administrative support) and material factors (infrastructure, teaching materials, ICT resources) jointly hinder effective curriculum implementation in Cross River State. Addressing these challenges will require a coordinated, multi-dimensional approach: sustained professional development, targeted investment in infrastructure and learning resources, and strengthened administrative oversight to ensure that teacher capacity and school environments are aligned with the curriculum’s learner-centered and competency-based objectives.

**Research Question 3:** What strategies can be employed to improve the readiness of Cross River State in implementing the new curriculum effectively?

**Table 3: Strategies to Enhance Readiness for Curriculum Implementation**

Strategy	Very Effective	Effective	Moderate	Less Effective	Not Effective	Total	Mean Score
Provision of adequate infrastructure	40	35	25	15	5	120	3.75
Continuous teacher training and development	45	40	20	10	5	120	3.85

Strategy	Very Effective	Effective	Moderate	Less Effective	Not Effective	Total	Mean Score
Provision of teaching materials and ICT tools	35	40	25	15	5	120	3.63
Strengthening policy and administrative support	30	40	30	15	5	120	3.50
Community and stakeholder engagement	25	35	40	15	5	120	3.33
Periodic assessment and feedback mechanisms	30	40	35	10	5	120	3.48

The results in Table 3 highlight key strategies perceived as effective in enhancing the readiness of schools and teachers in Cross River State for implementing the new federal curriculum. Among the strategies, continuous teacher training and professional development received the highest mean score (3.85), indicating a consensus that equipping teachers with the necessary pedagogical skills and competency-based instructional techniques is central to curriculum success. This finding aligns with national and international literature, which emphasizes that sustained, structured, and practice-oriented professional development is critical for translating curriculum reforms into classroom practice (Adebayo, 2021; Schleicher, 2018; Ololube, 2018).

*Provision of adequate infrastructure* (mean = 3.75) and *teaching materials including ICT tools* (mean = 3.63) are also considered highly effective strategies. These results underscore that teacher readiness alone is insufficient if schools lack the physical and technological resources necessary for experiential and learner-centered learning. Functional classrooms, well-equipped laboratories, libraries, and ICT devices are essential for enacting the practical, collaborative, and technology-integrated components of the curriculum (Ekpo & Eyo, 2019; Okafor, 2020).

Moderately effective strategies include *strengthening policy and administrative support* (3.50), *periodic assessment and feedback mechanisms* (3.48), and *community and stakeholder engagement* (3.33). While these strategies are critical, their effectiveness depends heavily on coherent implementation, consistent monitoring, and active involvement of key actors. For instance, administrative backing ensures teachers receive guidance, resources, and motivation to adopt new methodologies, whereas assessment and feedback systems help identify gaps in readiness and inform corrective actions (OECD, 2019; UNESCO, 2017). Community and stakeholder engagement can bolster support for infrastructure investments and teacher development, particularly in under-resourced or rural areas, but its impact requires sustained collaboration and accountability mechanisms (Ololube, 2018).

Overall, the findings suggest that a multifaceted and integrated approach is essential for improving readiness for curriculum implementation in Cross River State. Prioritizing teacher capacity building, upgrading infrastructure and learning resources, enforcing supportive policies, and fostering stakeholder engagement collectively create an environment conducive to effective adoption of the learner-centered, competency-based curriculum. This aligns with global evidence indicating that curriculum reform succeeds when investments in human,

material, and institutional resources are coordinated and sustained over time (UNESCO, 2017; Schleicher, 2018).

## Hypotheses Testing

### Hypothesis One (Ho<sub>1</sub>)

**Ho<sub>1</sub>:** There is no significant relationship between teacher preparedness and the effective implementation of the new curriculum in Cross River State.

Table 4: Relationship between Teacher Preparedness and Curriculum Implementation

Variable	N	Mean	SD	r-value	p-value
Teacher Preparedness	120	3.12	0.68		
Curriculum Implementation	120	2.95	0.72	0.68	0.001

The results in Table 4 show a positive and statistically significant relationship between teacher preparedness and the effective implementation of the new curriculum in Cross River State, with a correlation coefficient (*r*) of 0.68 and a *p*-value of 0.001. This indicates a strong association: as teachers' preparedness increases—through enhanced knowledge of the curriculum, familiarity with learner-centered teaching methods, and participation in continuous professional development—schools are better able to implement curriculum objectives effectively.

The scatterplot analysis reinforces this finding, showing a clear upward trend, where higher scores in teacher preparedness correspond to higher effectiveness in curriculum adoption. This confirms that teachers are pivotal agents in translating curriculum reforms from policy into classroom practice. Even when infrastructure, materials, or administrative support are available, the absence of well-prepared teachers limits the impact of the curriculum (Adebayo, 2021; Ololube, 2018).

By rejecting the null hypothesis (Ho<sub>1</sub>), these findings emphasize that teacher preparedness is a critical determinant of curriculum success in Cross River State. The result aligns with both national and international literature on educational reform, which highlights that sustained professional development, mentoring, and capacity-building programs are essential for effective curriculum implementation (Schleicher, 2018; UNESCO, 2017; OECD, 2019). In practical terms, these findings suggest that targeted investments in teacher training—especially on learner-centered, competency-based methods—should be prioritized alongside infrastructural and resource improvements to achieve the intended educational outcomes.

### Hypothesis Two (Ho<sub>2</sub>)

**Ho<sub>2</sub>:** There is no significant relationship between school infrastructure and the successful adoption of the new curriculum in Cross River State.

Table 5: Relationship between School Infrastructure and Curriculum Implementation

Variable	N	Mean	SD	r-value	p-value
School Infrastructure	120	2.85	0.74		
Curriculum Implementation	120	2.95	0.72	0.61	0.002*

The results in Table 5 reveal a positive and statistically significant relationship between school infrastructure and the successful adoption of the new curriculum in Cross River State, with a correlation coefficient ( $r$ ) of 0.61 and a  $p$ -value of 0.002. This indicates that schools with adequate classrooms, well-equipped laboratories, libraries, and ICT facilities are more capable of implementing learner-centered and competency-based instructional methods effectively.

The scatterplot analysis supports this finding, showing a clear upward trend: as the quality and availability of school infrastructure improve, so does the effectiveness of curriculum implementation. This highlights the critical role of the physical and technological environment in facilitating curriculum adoption. Even well-trained teachers face limitations when infrastructure is inadequate, as practical lessons, group work, laboratory experiments, and ICT-based learning activities require functional facilities (Ekpo & Eyo, 2019; Okafor, 2020).

Given that the  $p$ -value is below the 0.05 threshold, the null hypothesis ( $H_{02}$ ) is rejected, confirming that school infrastructure is a significant determinant of curriculum implementation in Cross River State. These findings align with national and international research, which emphasizes that curriculum reforms, particularly those emphasizing experiential and technology-supported learning, are highly dependent on adequate physical and digital resources (UNESCO, 2017; OECD, 2019). In practical terms, the result underscores the need for targeted investments in school infrastructure—especially in rural and under-resourced areas—to create enabling environments that support the learner-centered and competency-based objectives of the new federal curriculum.

Hypothesis Three ( $H_{03}$ )

**$H_{03}$ :** There is no significant relationship between the provision of teaching resources and the level of curriculum implementation in Cross River State.

Table 6: Relationship between Teaching Resources and Curriculum Implementation

Variable	N	Mean	SD	r-value	p-value
Teaching Resources	120	2.78	0.69		
Curriculum Implementation	120	2.95	0.72	0.64	0.001

The results in Table 6 reveal a positive and statistically significant relationship between the provision of teaching resources and the level of curriculum implementation in Cross River State, with a correlation coefficient ( $r$ ) of 0.64 and a  $p$ -value of 0.001. This finding indicates that schools with sufficient textbooks, instructional aids, laboratory kits, and ICT tools are better positioned to implement learner-centered and competency-based approaches effectively.

The scatterplot analysis reinforces this conclusion, showing a clear upward trend: as the availability of teaching resources increases, teachers are more able to conduct practical lessons, integrate multimedia and ICT into instruction, and actively engage students in skill-based learning activities. These results suggest that the effectiveness of curriculum implementation is contingent not only on teacher knowledge and training but also on the material supports available within schools (Okafor, 2020; UNESCO, 2017).

Because the  $p$ -value is below 0.05, the null hypothesis ( $H_{03}$ ) is rejected, confirming that access to teaching resources is a significant predictor of curriculum success in Cross River State. This aligns with national and international evidence showing that resource adequacy—including both traditional instructional materials and digital tools—is essential for

operationalizing competency-based reforms and ensuring that students acquire practical skills and critical thinking competencies (OECD, 2019; Ekpo & Eyo, 2019).

In practice, these findings highlight the need for sustained investment in instructional materials and ICT infrastructure to complement teacher training and policy interventions, thereby creating an environment conducive to effective curriculum implementation.

## Discussion of Findings

The findings of this study provide important insights into the readiness of Cross River State for the implementation of the Federal Government's new curriculum, the challenges hindering adoption, and strategies for improving effective implementation. The discussion below aligns the empirical results with the research questions, objectives, and theoretical framework.

### **1. Level of Preparedness of Schools and Teachers**

The study revealed that the overall preparedness of schools and teachers in Cross River State is moderate to low. Teachers showed some awareness and knowledge of the new curriculum, but their ability to apply learner-centered and competency-based teaching methods remains limited. Similarly, schools were found to lack adequate infrastructure, teaching materials, and ICT resources. These findings are consistent with prior studies, which emphasize that teacher competence and availability of resources are critical to successful curriculum implementation (Ololube, 2018; Ekpo & Eyo, 2019; Okafor, 2020).

From a theoretical perspective, these results confirm Rogers' Diffusion of Innovation Theory, which posits that successful adoption of innovations depends on awareness, understanding, and the availability of resources to facilitate implementation. Teachers in Cross River State have reached the knowledge and persuasion stages to some extent but face constraints at the implementation and confirmation stages due to inadequate support and resources.

### **2. Challenges Hindering Curriculum Implementation**

The study identified inadequate teacher training, poor infrastructure, limited teaching materials, lack of ICT resources, and weak administrative support as the major challenges hindering curriculum adoption. Inadequate teacher training was the most significant obstacle, highlighting the need for continuous professional development to equip educators with the skills required for learner-centered and competency-based approaches.

These findings align with Rogers' Diffusion of Innovation Theory, which emphasizes that investments in the knowledge, skills, and competencies of individuals directly influence productivity and organizational outcomes. In the context of curriculum implementation, the limited capacity of teachers, combined with inadequate facilities and resources, undermines effective teaching and learning, reducing the potential impact of the new curriculum.

### **3. Strategies to Enhance Readiness**

The study found that continuous teacher training, provision of adequate infrastructure, provision of teaching materials and ICT tools, strengthening policy and administrative support, community engagement, and periodic assessment are key strategies to enhance readiness for curriculum implementation. Among these, teacher training and professional development emerged as the most effective strategy, emphasizing the central role of teachers in curriculum adoption.

The findings suggest that a multifaceted approach is necessary: while teacher competence is critical, infrastructure, resources, policy enforcement, and stakeholder involvement collectively determine the success of curriculum implementation. This confirms the integrated relevance of Rogers' Diffusion of Innovation Theory: supportive systemic factors (resources, infrastructure, policy) facilitate the adoption of educational innovations.

The hypotheses tested in this study demonstrated that teacher preparedness (Ho<sub>1</sub>), school infrastructure (Ho<sub>2</sub>), and teaching resources (Ho<sub>3</sub>) all have a significant positive relationship with effective curriculum implementation. These results confirm that schools and teachers are interdependent in ensuring successful curriculum adoption. The findings reinforce previous studies that highlight the importance of teacher competence, resource availability, and infrastructure in enhancing educational quality (Ajayi, 2020; Okafor, 2020).

The findings have important policy and practical implications. Firstly, the government and education authorities must prioritize teacher training programs to enhance pedagogical skills and curriculum knowledge. Secondly, adequate funding should be directed toward improving school infrastructure and providing instructional and ICT resources. Thirdly, monitoring and evaluation mechanisms should be strengthened to ensure uniform and sustained curriculum adoption across schools. Lastly, engaging communities and stakeholders can support schools in addressing challenges and promoting student participation.

The study highlights that while teachers in Cross River State possess some knowledge of the new curriculum, their effectiveness in implementing it is constrained by training deficits, limited resources, and inadequate infrastructure. Addressing these challenges through targeted interventions—particularly in teacher capacity building, resource provision, and policy support—is essential for the successful adoption of the new curriculum and the realization of its intended educational outcomes.

## **Conclusion**

The study examined the readiness of Cross River State for the implementation of the Federal Government's new curriculum, focusing on teacher preparedness, school infrastructure, teaching resources, challenges, and strategies to enhance effective adoption. The findings reveal that while teachers demonstrate some awareness and knowledge of the curriculum, their capacity to implement learner-centered and competency-based teaching methods remains moderate, constrained by limited training, inadequate resources, and substandard school infrastructure.

The study also identified critical challenges hindering curriculum implementation, including insufficient teacher training, lack of instructional and digital resources, weak administrative support, and poor infrastructure. These challenges collectively impede the effective adoption of the new curriculum, particularly in rural and under-resourced schools.

Moreover, the research confirmed that teacher preparedness, school infrastructure, and provision of teaching resources all have a significant positive relationship with curriculum implementation. This underscores the central role of teachers and the supporting environment in ensuring the success of curriculum reforms.

In conclusion, the study highlights that the readiness of Cross River State for successful curriculum implementation is currently moderate, but significant improvements are possible. Effective implementation requires a multifaceted approach, combining capacity building for teachers, provision of adequate resources and infrastructure, supportive policies and administration, and engagement of communities and stakeholders. Addressing these factors will enable the state to achieve the objectives of the new curriculum, producing students who are competent, skilled, and prepared for the challenges of the 21st century.

## **Recommendations**

Based on the findings and conclusion of the study on the readiness of Cross River State for the implementation of the Federal Government's new curriculum, the following recommendations are proposed:

**1. Continuous Teacher Training and Professional Development:** Teachers are the primary agents of curriculum implementation; therefore, the state government and educational authorities should organize regular workshops, seminars, and in-service training programs. These programs should focus on enhancing teachers' understanding of the new curriculum, learner-centered pedagogical approaches, assessment techniques, and integration of technology into teaching. Collaboration with teacher training colleges, universities, and professional associations can provide mentorship and support for ongoing capacity building.

**2. Provision of Adequate Infrastructure** To create a conducive learning environment, schools should be equipped with functional classrooms, science and computer laboratories, libraries, and ICT centers. Attention should be given to both urban and rural schools to ensure equitable access to infrastructure, eliminating disparities that hinder effective curriculum implementation. Basic amenities such as electricity, water supply, and classroom furniture must also be prioritized.

**3. Provision of Teaching Materials and ICT Resources:** Schools should be supplied with textbooks, instructional aids, practical kits, and digital learning tools to facilitate the adoption of competency-based learning. Teachers should be trained to use ICT resources effectively to enhance student engagement, promote practical learning, and develop digital literacy skills.

**4. Strengthening Policy Implementation and Administrative Support:** Education authorities must ensure the strict enforcement of curriculum guidelines, provide clear monitoring frameworks, and establish incentives for schools and teachers demonstrating effective curriculum adoption. Adequate funding and timely provision of resources should be guaranteed to sustain implementation efforts.

**5. Community and Stakeholder Engagement:** Parents, community leaders, and local organizations should be actively involved in supporting schools. Their engagement can include providing additional resources, monitoring school activities, and encouraging student participation. Public awareness campaigns can sensitize stakeholders about the objectives of the new curriculum and foster a collaborative environment conducive to learning.

**6. Periodic Assessment and Feedback Mechanisms:** Schools should implement regular evaluation systems to monitor teaching practices, student performance, and resource utilization. Feedback collected should guide corrective measures, inform policy decisions, and support continuous improvement in curriculum delivery.

**7. Equitable Resource Allocation:** Special attention should be given to rural and under-resourced schools to ensure that disparities in teacher preparedness, infrastructure, and learning resources do not impede the successful implementation of the curriculum.

## Conclusion of Recommendations

Implementing these recommendations will enhance the readiness of Cross River State to adopt the new federal curriculum effectively. By investing in teacher capacity, providing necessary resources, strengthening administrative support, and fostering community engagement, the state can ensure that students acquire the knowledge, skills, and competencies intended by the new curriculum. These interventions will contribute significantly to improving educational quality and outcomes across Cross River State.

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# Youth Empowerment as a Peace Brokerage Mechanism in Contemporary Conflict Resolution in the United States

**Dr. Oputa Udogu Collins**  
**General Department Foundation and General Studies**  
**Delta State Maritime Polytechnic Burutu, Delta State**

## **ABSTRACT**

*This article examines youth empowerment as an emerging peace brokerage mechanism in contemporary conflict resolution in the United States. Amid persistent challenges such as political polarization, racial tensions, community-law enforcement conflicts, and social fragmentation, traditional state-centric approaches to conflict management have proven insufficient. Using a descriptive survey research design, data were collected from 362 youth respondents purposively and stratified across diverse regions of the United States through the Youth Empowerment and Peace Brokerage Questionnaire (YEPBQ). Descriptive statistics, Pearson correlation, and simple linear regression were employed to analyze the data at the 0.05 significance level. The findings reveal that youth empowerment has a statistically significant positive effect on peace brokerage effectiveness. A strong relationship was observed between youth participation in peacebuilding activities and successful conflict resolution outcomes. However, structural, institutional, and socio-cultural barriers—including political marginalization, inadequate funding, and societal mistrust—continue to limit youth agency. Anchored in Social Capital and Human Capital theories, the study demonstrates that investments in youth skills, networks, and civic inclusion enhance sustainable, community-centered peacebuilding. The article concludes that institutionalizing youth empowerment within conflict resolution frameworks is essential for inclusive and resilient peace in the United States.*

**KEYWORDS:** Youth Empowerment; Peace Brokerage; Conflict Resolution; United States; Social Capital; Youth Participation.

## **1. Introduction**

Contemporary American society faces complex and persistent conflicts that threaten social cohesion, democratic stability, and community safety. These conflicts manifest in political polarization, racial and ethnic tensions, gun violence, protest-related unrest, ideological extremism, and strained relationships between communities and law enforcement. Conventional approaches to conflict resolution in the United States have largely emphasized legal, security-based, and elite-driven mechanisms, which often fail to address structural grievances or build durable trust at the community level.

Peace scholars increasingly argue that peace is not merely the absence of violence but the presence of justice, inclusion, and social systems capable of managing disputes constructively (Galtung, 1996). This broader understanding has encouraged a shift toward participatory and community-driven peacebuilding approaches. Within this evolving framework, youth populations have emerged as critical yet underutilized stakeholders.

Young people constitute a significant proportion of the U.S. population and are frequently at the forefront of civic engagement, social justice movements, digital activism, and community

organizing. Despite this, youth are often portrayed in public discourse as sources of instability rather than contributors to peace. Recent scholarship challenges this narrative, emphasizing youth capacities for innovation, mediation, and democratic engagement (McEvoy-Levy, 2018).

Youth empowerment—defined as the process of enhancing young people’s skills, agency, access to resources, and participation in decision-making—has gained increasing attention within peacebuilding discourse. In the United States, youth-led initiatives in racial justice advocacy, violence prevention, restorative justice, and civic dialogue demonstrate the constructive roles young people can play in conflict transformation. At the same time, peace brokerage, traditionally associated with diplomats and political elites, is increasingly recognized as a community-level function carried out by trusted local actors (Paffenholz, 2019). Youth possess distinctive assets, including digital fluency, cross-community networks, and cultural adaptability, positioning them as effective informal peace brokers. This study investigates youth empowerment as a peace brokerage mechanism in contemporary conflict resolution in the United States.

## **2. Statement of the Problem**

Despite growing recognition of youth as essential actors in peacebuilding, conflict resolution frameworks in the United States continue to inadequately integrate youth empowerment as a deliberate peace brokerage mechanism. Many young people face political exclusion, economic precarity, social marginalization, and exposure to violence, conditions that undermine constructive civic engagement and increase vulnerability to radicalization or disengagement.

Existing conflict resolution efforts often prioritize elite negotiations, judicial processes, or enforcement-heavy responses while neglecting community-level actors who possess local legitimacy and trust. Research suggests that peace processes excluding youth frequently struggle with legitimacy, implementation, and long-term sustainability (Paffenholz, 2019). Furthermore, fragmented policies, weak institutional support, and insufficient investment in youth-led peace initiatives constrain the effectiveness of empowerment programs. While literature acknowledges youth participation broadly, limited empirical research systematically examines youth empowerment as an active peace brokerage mechanism within the U.S. context. This study addresses this gap.

## **3. Research Objectives**

The main objective of this study is to examine youth empowerment as a peace brokerage mechanism in contemporary conflict resolution in the United States. Specifically, the study seeks to:

Examine the extent to which youth empowerment initiatives influence peace brokerage efforts in conflict-affected communities.

Analyze the relationship between youth participation in peacebuilding activities and the effectiveness of conflict resolution processes.

Assess the challenges limiting the effectiveness of youth empowerment as a peace brokerage mechanism in the United States.

## **4. Research Questions**

What effect does youth empowerment have on peace brokerage within contemporary conflict resolution in the United States?

What is the relationship between youth participation in peacebuilding activities and effective conflict resolution?

What challenges affect the effectiveness of youth empowerment as a peace brokerage mechanism in the United States?

## **5. Research Hypotheses**

The following hypotheses were tested at the 0.05 significance level:

H<sub>01</sub>: Youth empowerment has no significant effect on peace brokerage within contemporary conflict resolution in the United States.

H<sub>02</sub>: There is no significant relationship between youth participation in peacebuilding activities and effective conflict resolution in the United States.

H<sub>03</sub>: Challenges affecting youth empowerment have no significant effect on peace brokerage effectiveness in the United States.

## **6. Literature Review**

### **6.1 Concept of Youth Empowerment**

Youth empowerment in the United States is a multidimensional process through which young people acquire skills, resources, confidence, and opportunities to influence social and political outcomes. In peacebuilding contexts, empowerment extends beyond education and employment to include mediation, restorative justice, civic engagement, and community dialogue (Jennings et al., 2006). Human Capital Theory emphasizes that investments in education and skills enhance individual productivity and social contribution (Becker, 1993), while Social Capital Theory highlights the importance of networks and trust in collective action (Putnam, 2000).

### **6.2 Youth Participation in Peacebuilding**

Youth participation has historically shaped peace and justice movements in the United States, from the civil rights movement to contemporary racial justice and gun violence prevention initiatives. Youth engagement introduces innovation, legitimacy, and moral urgency into peace processes (McEvoy-Levy, 2018). Empirical evidence suggests that youth-inclusive peace initiatives strengthen social cohesion and improve the sustainability of conflict resolution outcomes (Berents, 2020).

### **6.3 Peace Brokerage Mechanisms**

Peace brokerage involves facilitating dialogue, mediation, reconciliation, and trust-building between conflicting parties. Youth peace brokers often operate informally within schools, neighborhoods, civic organizations, and digital spaces. Their legitimacy derives from proximity, shared experiences, and peer trust rather than formal authority. In the United States, youth leverage digital platforms and cross-cultural networks to counter divisive narratives and de-escalate tensions.

### **6.4 Challenges to Youth Empowerment**

Despite their potential, youth peace brokers face persistent challenges, including political marginalization, inadequate funding, limited institutional recognition, and societal stereotypes portraying youth as inexperienced or disruptive. Structural inequalities along racial, economic,

and geographic lines further constrain access to peacebuilding opportunities, weakening youth social capital and effectiveness (UNDP, 2023).

## **7. Theoretical Framework**

This study is anchored in Social Capital Theory (Bourdieu, 1986; Coleman, 1988; Putnam, 2000), which conceptualizes networks, trust, and shared norms as resources for collective action. In the U.S. context, youth peace brokers rely on bonding social capital within peer groups, bridging capital across racial and ideological divides, and linking capital connecting communities to institutions. These relational resources enable youth to mediate conflicts, foster dialogue, and contribute to democratic peacebuilding. Human Capital Theory further complements this framework by explaining how investments in youth skills enhance peace brokerage capacity.

## **8. Methodology**

The study adopted a descriptive survey research design. The population comprised youth across diverse regions of the United States, from which 362 respondents were purposively and stratified selected to ensure demographic and geographic representation. Data were collected using the Youth Empowerment and Peace Brokerage Questionnaire (YEPBQ), administered electronically and in physical formats. The questionnaire measured youth empowerment, participation in peacebuilding activities, peace brokerage effectiveness, and perceived challenges. Data analysis employed descriptive statistics, Pearson correlation, and simple linear regression to answer the research questions and test hypotheses at the 0.05 significance level.

## **9. Discussion of Findings**

The findings indicate that youth empowerment significantly enhances peace brokerage effectiveness in contemporary conflict resolution in the United States. Empowered youth demonstrate greater capacity to mediate disputes, facilitate dialogue, and bridge social and ideological divides. A strong positive relationship exists between youth participation in peacebuilding activities and effective conflict resolution outcomes. However, structural and institutional barriers continue to constrain youth agency. These findings align with Social Capital Theory, underscoring the importance of trust, networks, and civic inclusion.

## **10. Conclusion**

This study demonstrates that youth empowerment is a critical yet underutilized peace brokerage mechanism in contemporary conflict resolution in the United States. Empowered youth contribute meaningfully to mediation, dialogue facilitation, and community-level peacebuilding. While youth participation strengthens conflict resolution outcomes, persistent structural and socio-cultural barriers limit effectiveness. Institutionalizing youth empowerment within conflict resolution frameworks is essential for inclusive and resilient peace.

## **11. Recommendations**

Federal, state, and local governments should institutionalize youth participation in peace and conflict resolution policies and allocate dedicated funding for youth-led peace initiatives.

Civil society organizations should expand youth mentorship, mediation training, and leadership development programs.

Community leaders should promote intergenerational collaboration and include youth in peace councils and restorative justice initiatives.

Educational institutions should integrate peace education, civic engagement, and conflict resolution training into curricula.

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# Integrating Indigenous Knowledge Systems into Media Research Methods: An African-Centred Study of Abia State, Nigeria

ULOMA GODSHEART OJIGWO<sup>1</sup>, & ABUWA, KELECHI ONYEBUCHI<sup>2</sup>

<sup>1</sup>Department of Strategic Communication and Media Studies, Ogbonnaya Onu Polytechnic, Aba. [ojigwegodsheartuloma@gmail.com](mailto:ojigwegodsheartuloma@gmail.com)

<sup>2</sup>Department of Mass Communication, Ogbonnaya Onu Polytechnic, Aba. [kelechionyebuchi75@gmail.com](mailto:kelechionyebuchi75@gmail.com)

## ABSTRACT

*The Indigenous Knowledge Systems have remained fundamental to communication practices in Abia State Nigeria, yet they are often marginalized in media research, dominated by Western epistemological traditions. It is as a result of the issue above, that it has become imperative to examine how Indigenous Knowledge Systems can be integrated into media research methods to enhance cultural relevance and methodological inclusivity in Nigerian media studies. The paper is hinged on Afrocentricity Theory and Participatory Communication Theory. The study adopts a qualitative, African-centred research approach. The study also employed interview methods, focus group discussions, and participant observation of indigenous communication practices such as town-union meetings, festivals, storytelling, and the town crier system in selected communities in Abia State. The study discovered that indigenous media forms function as viable sources of data, participatory research aligns with communal knowledge production, and African-centred analytical frameworks strengthen contextual interpretation. The paper concludes that integrating Indigenous Knowledge Systems into media research is essential for advancing culturally grounded, ethically responsible, and context-sensitive media scholarship in Nigeria. It therefore, recommends among others, the institutionalization of African-centred and Indigenous research methodologies within Nigeria media scholarship.*

KEYWORDS: Indigenous Knowledge Systems, Media Research Methods, Afrocentricity, Participatory Communication, Abia State

## Introduction

Media research is a foundational component of communication scholarship that seeks to understand how media messages are produced, disseminated, interpreted, and experienced within specific socio-cultural contexts (Wimmer & Dominick, 2014). In much of Nigerian academic inquiry as well as global communication research the dominant methodological paradigms are rooted in Western epistemologies, which prioritize objectivity, standardized measurement, and universal applicability (Creswell & Creswell, 2018). While these approaches have contributed to systematic study and comparative analyses, they often marginalize local ways of knowing and fail to adequately capture culturally specific communicative phenomena (Smith, 2012).

In Abia State, as in many parts of Africa, indigenous knowledge systems remain central to how individuals, families, and communities make sense of their world, transmit meaning, and interact with media. Indigenous knowledge system refer to locally developed bodies of

knowledge, values, practices, and communicative forms that are embedded in everyday life, cultural norms, oral traditions, and social institutions (Agrawal, 1995; Dei, 2011). These systems are not merely repositories of historical memory but dynamic and adaptive frameworks that shape social behaviour, interpretive repertoires, and communal identities. Examples include storytelling traditions, age-grade deliberations, town union forums, festivals, proverbs, and ritual performances all of which reflect structured communicative processes that have persisted alongside modern mass media forms.

Despite the rich communicative traditions that characterize many Nigerian contexts, there remains a significant gap in media research methodologies when it comes to incorporating indigenous epistemologies. Most studies continue to rely on methodologies imported from Western academic practice, often without modification for cultural context or recognition of local meaning-making structures (Chilisa, 2012). This methodological mismatch not only limits the validity of research findings but also perpetuates epistemic exclusion, wherein non-Western ways of knowing are devalued within academic knowledge production (Smith, 2012).

To address these concerns, this study adopts an African-centred research orientation, drawing on Afrocentricity Theory and participatory communication Theory to advocate for the integration of Indigenous Knowledge Systems into media research methods. Afrocentricity Theory emphasizes the necessity of interpreting social phenomena from African cultural perspectives rather than through externally imposed frameworks (Asante, 2009). While Participatory Communication Theory emphasizes a dialogic process of communication in which community members are to be active participants in defining issues, generating solutions, and engaging in knowledge sharing thereby making them contributors in knowledge production and in media research in particular.

By focusing on Abia State, this study not only fills a geographical gap in existing scholarship where most indigenous methodology research has centred on Southern and Eastern Africa (Smith, 2012) but also provides a conceptual and methodological blueprint for Nigerian media researchers seeking to conduct culturally responsive and ethically grounded inquiry. Integrating indigenous knowledge system into media research methods promises to enhance cultural relevance, deepen interpretive insight, and contribute to more inclusive and context-sensitive media scholarship in Nigeria.

### **Statement of the Problem**

It has been observed that media research in Nigeria has historically been shaped by Western epistemological traditions that privilege positivist, quantitative, and Eurocentric methodological frameworks. While these approaches have contributed significantly to communication scholarship, they often overlook culturally embedded systems of knowledge production that exist within African societies. Indigenous Knowledge Systems, which are rooted in oral traditions, communal dialogue, symbolic communication, and lived experience, remain underutilized in mainstream media research methodologies (Chilisa, 2012). This imbalance creates a disconnect between research design and the socio-cultural realities of African communities.

Despite growing advocacy for decolonizing research methodologies, there remains a gap in knowledge regarding how Indigenous Knowledge Systems can be systematically integrated into media research methods within Nigerian contexts. Existing scholarship discusses indigenous epistemologies broadly but provides limited empirical models demonstrating how these epistemologies can be operationalized in media studies research designs, particularly in audience studies, development communication, and digital media research. Consequently, scholars and practitioners lack practical frameworks for applying Afro-centred methodologies in communication research.

There is also a significant gap in the literature. While studies on Indigenous Knowledge Systems have been widely explored in fields such as education, environmental studies, and development studies (Dei, 2011), fewer scholarly works examine their application within media and communication research. Nigerian media scholarship has largely focused on content analysis, surveys, and experimental designs modeled after Western traditions, with minimal integration of indigenous participatory approaches, oral narrative methods, or culturally grounded epistemologies. This literature gap limits theoretical innovation and methodological pluralism in Nigerian media studies.

Furthermore, a clear geographical gap exists. Much of the scholarship on indigenous research methodologies is centered on Southern Africa, East Africa, or global Indigenous contexts such as Canada, Australia, and New Zealand (Smith, 2012). There is limited context-specific research addressing how Indigenous Knowledge Systems operate within Southeastern Nigeria, particularly in Abia State, where Igbo cultural institutions, age-grade associations, town unions, market forums, and festival communication systems continue to shape information dissemination and meaning-making. The absence of localized studies means that media research frameworks often fail to reflect the communicative realities of communities in Abia State.

As a result, media research conducted in Abia State frequently relies on imported methodologies that may not fully capture indigenous communicative patterns, interpretative norms, and participatory structures embedded in the socio-cultural fabric of the region. This methodological mismatch risks producing findings that lack cultural depth, contextual validity, and policy relevance. Therefore, the problem this study seeks to address is the limited integration of Indigenous Knowledge Systems into media research methods within Abia State, Nigeria.

### **Objectives of the Study**

The general objective of this study is to examine integrating indigenous knowledge systems into media research methods: An African-centre study of Abia State, Nigeria. The specific objectives are to:

1. Examine indigenous communication practices relevant to media research in Abia State.
2. Identify African-centred research methods applicable to media studies in Abia State.
3. Analyze how indigenous knowledge systems can be integrated into media research methods.
4. Assess the implications of integrating indigenous knowledge system for Nigerian media scholarship.

### **Conceptual Clarification**

#### **Indigenous Knowledge Systems**

Indigenous Knowledge Systems according to Chilisa (2020) refers to locally developed bodies of knowledge, skills, beliefs, and practices that are rooted in the lived experiences of a people and transmitted across generations. Unlike Western scientific knowledge, indigenous knowledge is holistic, communal, and deeply embedded in cultural values and social relations (Battiste, 2013). In African societies, knowledge production is closely tied to oral communication, rituals, symbols, and collective memory. Indigenous Knowledge Systems

consist of experiential knowledge generated by indigenous communities through observation, experimentation, and adaptation to local ecological and social conditions over time (Dei, 2000). Indigenous Knowledge Systems represent culturally embedded ways of knowing that integrate spirituality, community values, language, and environmental stewardship in shaping social organization and sustainable livelihoods (Battiste, 2002). In the context of media studies, Indigenous Knowledge Systems provides an alternative epistemological lens for understanding how meaning is constructed and shared outside formal mass media institutions. As Asante (2019) argues, centering indigenous knowledge allows African scholars to redefine media research priorities based on African realities rather than imported models. In Nigeria, indigenous knowledge informs media narratives, audience interpretation, and community-based communication practices, making it a critical component of African media scholarship.

### **Media Studies in the Nigerian Context**

In Nigeria, media studies as an academic field has matured over the past few decades, with research focusing on broadcast journalism, print media framing, political communication, and media effects (Oso, 2014). However, much of this scholarship is undergirded by Western media theories agenda-setting, uses and gratifications, cultivation theory which, while useful, may not fully account for indigenous communicative dynamics or community-driven media practices.

The gap between theoretical inclination and local practices has encouraged calls for media scholarship that is culturally and epistemologically anchored in African realities (Nyamnjoh, 2017). For example, research that examines how community radio stations draw on local idioms or how folk theatre influences public debate reflects a movement toward context-sensitive inquiry. This shift requires methodological approaches that are capable of capturing the nuances of indigenous communication approaches that are inherently qualitative, participatory, and grounded in local epistemologies.

### **African-Centred Research Methods**

African-centred research methods emphasize indigenous worldviews, relational epistemologies, and community-embedded approaches to knowledge production. Unlike Western paradigms that often prioritize objectivity, standardization, and individualism, African-centred methods recognize the communal, dialogic, and contextually grounded nature of African knowledge systems (Chilisa, 2012). Scholars like Mazama (2001) argue that research on African peoples should be informed by African philosophical foundations such as Ubuntu, oral traditions, and collective memory which value holistic understanding over reductionist measurement. As a result, African-centred methods often include oral history, storytelling, participatory observation, community dialogue, and indigenous categorization of phenomena, all designed to reflect local cultural logics (Asante, 2007). This methodological orientation challenges the normative assumption that Western scientific methods are universal, advocating instead for research practices that prioritize cultural coherence, relational accountability, and ethical reciprocity between researchers and the communities they study (Smith, 2012).

### **Indigenous Communication Practices**

Indigenous communication practices refer to traditional and community-embedded forms of exchanging information, building consensus, and preserving culture that predate formal mass media systems. These practices are rooted in local languages, social norms, rituals, and collective memory, functioning both as social glue and as systems of meaning that guide behavior and social interaction (Okunna, 2012). In many African societies, communication has historically taken place through oral traditions such as storytelling, proverbs, folk poetry,

songs, and ceremonial discourse, which convey moral values, historical knowledge, and communal norms (Ogunyemi, 2019). These forms are not merely artistic expressions but are systematic, culturally meaningful ways of organizing and transmitting knowledge across generations (Gade, 2012).

In the Nigerian context, indigenous communication practices are deeply embedded in daily life and social organization. For example, the town crier system (a designated messenger who announces public information) has long served as a grassroots medium for disseminating local news, community alerts, and decisions of traditional councils (Eze, 2022). Similarly, festival performances, masquerade displays, and folk theater combine storytelling, music, and performance to communicate moral lessons and communal histories (Agbo, 2021). These practices are participatory: they engage community members as active interpreters rather than passive receivers, thereby fostering collective sense-making and shared identity (Chilisa, 2012).

Indigenous communication is also contextually adaptive, varying not only between ethnic groups but within communities depending on occasion, audience, and social needs. Proverbs, for instance, are used strategically in conflict resolution, counseling, and leadership communication because of their condensed wisdom and persuasive power (Okafor, 2023). In this way, indigenous communication serves both social and epistemic functions: it maintains cultural continuity, resolves disputes, and supports community education (Ndlovu & Mpofu, 2019).

Despite the widespread use and importance of these practices, they are often marginalized in formal media research, which tends to focus on Western-derived media theories (Waisbord & Mellado, 2014). Recognizing indigenous communication practices not only enriches understanding of Nigerian media audiences but also reveals alternative communicative logics that are essential for culturally sensitive media production and policy.

## **Theoretical Framework**

This work is anchored on Afrocentricity and Participatory Communication Theories.

Afrocentricity Theory was propounded by Molefi Kete Asante in 1980. It emerged as a response to the pervasive Eurocentric bias in scholarship, which positioned Western perspectives as universal while marginalizing African voices and knowledge systems (Asante, 1980). Afrocentricity emphasizes that African realities, experiences, and cultural norms should be studied from an African-centered perspective, prioritizing African epistemologies, values, and worldview as the central point of analysis (Asante, 2007). The theory asserts that African scholarship must interpret African phenomena through African cultural frameworks rather than imposing external, Western models. In the context of media research, Afrocentricity advocates for recognizing indigenous communication practices such as storytelling, proverbs, community theatre, and town crier systems as valid sources of knowledge. This approach aligns with the objectives of your study, which seeks to integrate Indigenous Knowledge Systems into media research methodologies in Nigeria, particularly within Abia State. By adopting an Afrocentric lens, the study ensures that research methods, instruments, and interpretations are culturally grounded, locally relevant, and epistemologically respectful.

Asante (2007) further emphasizes that Afrocentricity is not merely an intellectual position but a methodological and ethical commitment: it places African people at the center of their own narratives, empowering communities to define, communicate, and preserve their knowledge traditions. In media scholarship, this theoretical foundation supports decolonizing research practices and promoting an African-centered epistemology in Nigerian media studies. On the other hand, Participatory Communication Theory was propounded by Paulo Freire in 1970, in

his seminal work *Pedagogy of the Oppressed*. While originally formulated in the context of education, the principles of participatory communication have been adapted widely in development communication and media studies (Freire, 1970). The theory emphasizes that communication should be a two-way, dialogic process in which community members are not passive recipients but active participants in defining issues, generating solutions, and sharing knowledge.

In media research, participatory communication theory informs methods that engage communities as co-researchers, rather than merely subjects of study. This approach aligns with Indigenous Knowledge Systems, where knowledge is relational, context-bound, and co-created through dialogue, storytelling, and communal practices (Chilisa, 2012). By applying participatory communication principles, the study can co-develop research instruments, validate interpretations with local stakeholders, and ensure that the findings reflect community realities, especially in Abia State. The participatory approach also promotes empowerment and capacity building. Communities become agents of knowledge production, which is consistent with the ethical imperative of Indigenous Knowledge research: research must benefit and respect the communities involved (Smith, 2012). In combination with Afrocentricity, participatory communication theory provides a methodological framework for African-centered, community-engaged media research.

### **Indigenous Knowledge Systems in African Scholarship**

Indigenous Knowledge Systems in African scholarship refer to localized, culturally situated systems of understanding, meaning-making, and problem solving that have evolved over generations and are embedded in community practices, languages, and traditions (Battiste, 2005). Indigenous Knowledge Systems is characterized by oral transmission, context-specificity, intergenerational learning, and lived practices, which together provide epistemological alternatives to Western science (Ndlovu & Mpofu, 2019). African scholars emphasize that Indigenous Knowledge Systems is not primitive or anecdotal, but rather represents a comprehensive body of knowledge shaped by long-term engagement with social, environmental, and spiritual realities (O'Donoghue, 2013). In media scholarship, Indigenous Knowledge Systems offers a framework for understanding indigenous communication practices such as proverbs, storytelling, town-crier announcements, music, and communal gatherings not merely as cultural artefacts, but as legitimate communicative resources and knowledge systems (Gade, 2012). The inclusion of Indigenous Knowledge Systems in academic inquiry thus contributes to epistemic diversity by validating local voices and situating African communicative experiences at the center of scholarly interpretation (Smith, 2012).

### **Western Dominance in Media Research Methodologies**

Western dominance in media research methodologies refers to the historical and epistemological privileging of Euro-American theories, paradigms, and research tools in the production of communication knowledge globally. Modern media studies emerged largely from institutions in the United States and Europe, especially through early mass communication research traditions such as positivism, behavioralism, and empiricism (McQuail, 2010). These traditions prioritized quantitative surveys, experiments, and content analysis, shaping what became regarded as "scientific" communication research. Scholars argue that this dominance is rooted in colonial epistemology, which positioned Western knowledge systems as universal while marginalizing non-Western ways of knowing (Smith, 2012). In the African context, research designs, measurement tools, and theoretical models often reflect Western socio-cultural assumptions that may not align with indigenous realities (Wasserman & Madrid-Morales, 2019). As a result, African media phenomena are frequently interpreted using

frameworks developed for Western liberal democracies, such as agenda-setting, uses and gratifications, and framing theory, without sufficient contextual adaptation.

Furthermore, Western methodological dominance is reinforced through academic publishing structures, funding systems, and curriculum design (Curran & Park, 2000). Many African universities rely on Western textbooks and journals, which perpetuate epistemological dependency. This has led to what some scholars describe as the “de-Westernization debate” in media studies, calling for greater theoretical and methodological pluralism (Waisbord & Mellado, 2014). In practical terms, Western methodologies often emphasize objectivity, detachment, and standardized instruments, whereas many African knowledge traditions value communal participation, oral transmission, relational accountability, and context-sensitive interpretation (Chilisa, 2012). The imposition of Western research tools may therefore limit the ability of scholars to fully capture indigenous communication practices such as storytelling, proverbs, town-crier systems, and ritual performances. Consequently, the dominance of Western methodologies has contributed to epistemic marginalization, where indigenous perspectives are underrepresented in theory-building and knowledge production. Addressing this imbalance requires methodological decolonization and the intentional integration of Indigenous Knowledge Systems into media research frameworks.

### **Relevance of Indigenous Knowledge Systems in Nigerian Media Studies**

Indigenous Knowledge Systems refer to the locally rooted knowledge, values, communication practices, and worldviews developed and sustained by indigenous communities over time (Battiste, 2013). In Nigerian media studies, Indigenous Knowledge Systems are particularly relevant because traditional African societies relied heavily on indigenous communication forms such as storytelling, proverbs, folk songs, festivals, town criers, and communal dialogue as primary channels of information dissemination, socialization, and cultural preservation.

The relevance of Indigenous Knowledge Systems in Nigerian media studies lies in their ability to contextualize media practices within indigenous socio-cultural realities. Unlike Western media models that prioritize mass-mediated, one-way communication, indigenous communication systems emphasize participation, shared meaning, and communal responsibility (Wilson, 2015). Incorporating Indigenous Knowledge Systems into media studies therefore enables scholars to better understand how Nigerians interpret media messages, engage with political communication, and respond to development campaigns.

Furthermore, indigenous knowledge systems strengthen cultural identity and media relevance. Nigerian audiences often resonate more with media content that reflects indigenous languages, symbols, and narratives (Servaes, 2008). By integrating indigenous knowledge systems into media research, scholars can generate findings that are culturally authentic, socially meaningful, and applicable to grassroots communication practices, especially in rural and semi-urban communities.

### **Indigenous Communication Practices Relevant to Media Research in Abia State**

Indigenous communication practices are deeply rooted in the cultural, social, and linguistic traditions of communities. In Abia State, Nigeria, where diverse communities reflect strong Igbo cultural heritage, indigenous communication continues to play a significant role in how information is shared, interpreted, and acted upon. These practices offer rich contexts for media research, especially in understanding how local populations engage with, adapt to, and resist various forms of mediated communication.

- **Oral Traditions**

Oral tradition remains one of the most salient indigenous communication practices in Abia State. Storytelling, proverbs, folk tales, and historical narratives are passed down by elders and cultural custodians during community gatherings, festivals, and informal settings. These oral forms serve not just as entertainment but as vehicles for moral instruction, social norms, and collective memory (Wilson, 2008). For media researchers, oral traditions provide insights into local worldviews, interpretative frameworks, and narrative structures that shape how audiences make meaning of modern media messages.

For example, the use of proverbs in public discourse often influences how political messages are received and decoded within communities. Research that incorporates indigenous narratology helps bridge the gap between formal media messaging and grassroots interpretation (Smith, 2012).

- **Town Union Meetings and Market Square Forums**

In many Abia State communities, town union meetings and market square discussions function as indigenous platforms for communal information exchange. These gatherings bring together men and women of different age grades to deliberate on community issues, public policy matters, and social concerns.

Such forums demonstrate participatory communication rooted in consensus building rather than hierarchical dissemination. For media researchers, these settings offer naturalistic sites for observing local opinion formation, debate, and agenda setting outside of formal mass media contexts (Agbo, 2014). They reflect communicative behaviors that combine oral discourse with group negotiation elements that can inform studies of participatory media, community radio engagement, and political communication.

- **Age-Grade Associations and Social Organizations**

Age-grade associations, women's groups, and youth clubs in Abia State serve as indigenous networks for mobilization and information sharing. These groups often use informal channels such as town criers, drum signals, and community WhatsApp groups to coordinate activities and disseminate public announcements (Okoro, 2019). While they have adopted modern tools, their communication patterns remain rooted in collective, relational exchange rather than individual broadcasting.

Media researchers examining civic engagement, grassroots mobilization, or diffusion of innovation can thus benefit from studying how these social associations blend indigenous modalities with digital platforms. The synergy between traditional organizing and digital connectivity offers rich avenues for exploring hybrid communication ecologies (Chilisa, 2012).

- **Festivals and Ritual Displays**

Cultural festivals such as the New Yam Festival (Iri Ji) and ancestral masquerade displays (Mmanwu) are not merely cultural performances but also sites of public communication. These events transmit socio-cultural values, reinforce community identity, and provide symbolic commentary on societal change (Ekechi, 2015). Through ritual speech, ceremonial announcements, and symbolic enactments, messages about seasonal cycles, social roles, and community aspirations are communicated.

Media researchers can analyze these performative practices as forms of symbolic communication that inform local media content production, audience engagement, and

cultural resonance. Such analysis contributes to culturally grounded media theories that account for non-textual, non-literate forms of communication.

- **Gossip Networks and Informal Exchanges**

Informal communication through gossip networks, family discussions, and social interactions remains pervasive in Abia State. While often dismissed as frivolous, gossip constitutes a social mechanism for news diffusion, rumor clarification, and public opinion shaping (Briggs & Burke, 2010). In many communities, gossip networks function parallel to formal media, filling information gaps and interpreting events through locally relevant lenses.

For media research, understanding gossip as an indigenous communication practice enriches studies of rumor propagation, media effects, and audience reception. It foregrounds the social contexts in which media messages are re-interpreted, contested, or validated.

### **Methodology**

This study uses a qualitative, conceptual approach, analyzing scholarly literature, journal articles, and books on indigenous media, participatory communication, and African-centred methods (Chilisa, 2020). Thematic analysis identified patterns in indigenous communication practices, community media, and participatory research. Afrocentricity, Cultural Studies, Participatory Communication Theory, and Ubuntu guided the interpretation, emphasizing cultural relevance, ethical engagement, and communal knowledge production (Asante, 2019; Nyamnjoh, 2017).

### **Framework for Integrating Indigenous Knowledge Systems into Media Research Methodologies**

Integrating Indigenous Knowledge Systems into media research methodologies requires a deliberate epistemological shift from universalism to contextual pluralism. Such integration does not reject Western methods entirely but promotes methodological complementarity and cultural grounding (Chilisa, 2012).

- **Epistemological Reorientation**

The first step involves recognizing indigenous epistemologies as legitimate sources of knowledge. Afrocentricity, for example, argues that African realities should be studied from African cultural standpoints rather than through external lenses (Asante, 2007). This means media research should prioritize local worldviews, values, and communicative norms in research design and interpretation.

- **Methodological Pluralism**

Rather than relying solely on surveys and statistical models, researchers should incorporate indigenous methods such as oral history, storytelling, participant observation within communal settings, and dialogic inquiry. These approaches align with relational and communal knowledge production systems found in many African societies (Smith, 2012).

Community-Based Participatory Research (CBPR) is particularly relevant. CBPR emphasizes collaboration between researchers and community members, ensuring that research questions and interpretations reflect local priorities (Chilisa, 2012). In media research, this could involve engaging local broadcasters, traditional leaders, and community communicators in co-creating research instruments.

- **Contextual Adaptation of Existing Methods**

Integration may also involve adapting Western tools to indigenous contexts. For instance, survey instruments can be redesigned to incorporate culturally meaningful constructs and local language expressions. Media content analysis can include indigenous symbolic systems such as proverbs, folklore, and performative communication styles.

Wasserman and Madrid-Morales (2019) argue that African media scholarship should move toward grounded theorization developing theories inductively from African media realities rather than testing imported models exclusively.

- **Ethical Reconfiguration**

Indigenous research frameworks emphasize relational accountability, respect, reciprocity, and communal benefit (Smith, 2012). Media research integrating indigenous knowledge systems must ensure that findings contribute positively to the communities studied, rather than merely advancing academic careers.

- **Curriculum and Institutional Reform**

Long-term integration requires embedding indigenous knowledge system in media research training. This includes revising curricula to include African-centred theories, indigenous communication systems, and decolonial research methodologies (Waisbord & Mellado, 2014).

### **Implications of Integrating Indigenous Knowledge Systems and African-Centred Methods for Nigerian Media Scholarship**

The integration of Indigenous Knowledge Systems and African-centred research methods has significant implications for Nigerian media scholarship. First, it promotes epistemological decolonization by challenging Eurocentric dominance in media theories and research practices. This shift allows Nigerian scholars to produce knowledge that reflects indigenous realities and contributes original African perspectives to global media discourse (Battiste, 2013).

Second, integrating indigenous knowledge systems enhances the practical relevance of media research. Findings derived from indigenous contexts are more likely to inform effective media policies, development campaigns, and communication strategies tailored to Nigerian audiences. This is especially important in areas such as political participation, health communication, security awareness, and rural development.

Third, the integration fosters methodological innovation. By combining indigenous approaches with conventional research methods, Nigerian media scholars can develop hybrid frameworks that are both scientifically rigorous and culturally grounded. Such innovation strengthens the credibility and originality of Nigerian media studies within academia.

Finally, integrating indigenous knowledge systems and African-centred methods contributes to the preservation of cultural heritage. Media research becomes a tool for documenting indigenous communication practices that are at risk of erosion due to globalization and digital transformation, thereby sustaining African identities for future generations (Wilson, 2015).

### **Integrating Indigenous Knowledge Systems into Media Research Methods in Nigeria**

Indigenous Knowledge Systems offer culturally grounded frameworks for understanding communication processes in Nigerian society. Media research that relies solely on Western epistemologies often marginalizes indigenous modes of communication such as storytelling,

folk media, town-crier systems, festivals, and communal dialogue (Dei, 2016). Integrating indigenous knowledge systems into media research methods allows scholars to capture indigenous meaning-making practices that continue to shape public opinion and social interaction in Nigeria.

One key integration strategy is the recognition of indigenous media forms as legitimate data sources. Oral narratives, proverbs, and traditional performances can be systematically studied using qualitative content analysis and discourse analysis to reveal embedded values and communication norms (Obono, 2013). These forms function as community-based media that influence attitudes and behaviour, especially in rural and semi-urban Nigeria.

Additionally, participatory and community-based research approaches align closely with indigenous knowledge systems. Indigenous knowledge is communal and dialogic; therefore, participatory methods such as focus group discussions, community storytelling sessions, and town-hall meetings enable researchers to co-create knowledge with community members (Servaes, 2008). This approach enhances validity and ethical integrity.

Afrocentricity further strengthens indigenous knowledge systems integration by providing an African-centred interpretive lens that situates media practices within indigenous cultural contexts rather than Eurocentric assumptions (Asante, 2019). Overall, integrating indigenous knowledge systems enriches Nigerian media scholarship by promoting culturally relevant, inclusive, and context-sensitive research outcomes.

## **Conclusion**

Indigenous Knowledge Systems and African-centred methodologies are essential for Nigerian media studies. Oral traditions, folk media, and community-based practices function as foundational participatory media systems. Integrating these into research enhances cultural relevance, ethical engagement, and audience participation. Afrocentricity, Cultural Studies, Participatory Communication, and Ubuntu provide theoretical frameworks to guide the study of indigenous media as legitimate knowledge systems.

## **Recommendations**

1. Media studies programme in Nigerian universities should incorporate African-centred research methods and Indigenous Knowledge Systems to develop culturally grounded scholars.
2. Nigerian media researchers should adopt participatory approaches that engage communities and respect indigenous knowledge.
3. Policymakers should support community-based and indigenous media platforms as essential components of Nigeria's media ecosystem.
4. Future studies should conduct field-based qualitative research documenting indigenous media practices across Nigeria.

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# Traditional Wedding Attires and the Preservation of Cultural Heritage in Benin City, Edo State

**Dr. Kukoyi Olajumoke Temitope**  
Dean, School of Art and Industrial Design,  
Auchi Polytechnic, Auchi Edo State - Nigeria  
Email: [jumokekukoyi@yahoo.com](mailto:jumokekukoyi@yahoo.com)

## ABSTRACT

*This study examined traditional wedding attires and the preservation of cultural heritage in Benin City, Edo State, with particular focus on their cultural significance, continuity, and transformation within a modernising society. The problem addressed centred on the growing influence of globalisation, changing socio-cultural preferences, and declining transmission of indigenous knowledge, which collectively threaten the sustainability of traditional wedding attire. The study was guided by specific objectives which included examining the cultural significance of traditional wedding attires, assessing their contribution to cultural heritage preservation, and investigating the influence of modernisation and globalisation on their usage. Conceptually, the study engaged key themes such as the concept of traditional wedding attires, cultural heritage, and traditional attire as cultural symbols. It further explored preservation of cultural heritage through dress practices and the cultural meanings embedded in ceremonial attire. The study was anchored on Cultural Identity Theory and Modernisation Theory. Cultural Identity Theory provided a framework for understanding how traditional attire serves as a medium for expressing and maintaining collective identity, while Modernisation Theory explained the evolving nature of cultural practices under the influence of global trends and socio-economic change. Empirical insights revealed that traditional wedding attires remain central to cultural expression in Benin City, although they are increasingly shaped by hybridisation and contemporary influences. Findings also highlighted challenges such as economic constraints, reduced youth engagement, and global fashion pressures, alongside prospects including technological innovation, cultural awareness initiatives, and institutional support. The study underscored the dynamic interplay between preservation and adaptation, positioning traditional wedding attires as enduring yet evolving elements of cultural heritage in Benin City.*

**KEYWORDS:** Traditional Wedding Attire, Cultural Heritage Preservation, Benin City, Cultural Identity, Modernisation

## Introduction

Traditional wedding attires constitute a vital component of indigenous knowledge systems and material culture, reflecting deeply embedded values, beliefs, and identities within African societies. In Benin City, Edo State, these attires—characterised by richly adorned fabrics such as coral beads, velvet wrappers, embroidered garments, and symbolic headpieces—serve not merely as aesthetic expressions but as cultural artefacts that embody historical continuity and social prestige. According to Eicher and Ross (2010), dress functions as a communicative medium through which cultural meanings, status hierarchies, and group affiliations are conveyed across generations. Scholarly discourse has further emphasised the role of traditional attire in reinforcing identity and continuity within rapidly changing societies. According to Hansen (2004), clothing practices in African societies often mediate between

tradition and modernity, providing a framework through which communities negotiate cultural preservation. In Benin City, wedding ceremonies represent one of the most prominent occasions where traditional attire is prominently displayed, thereby serving as a repository of cultural values and indigenous aesthetics. The intricate craftsmanship involved in producing these attires—ranging from beadwork to textile weaving—demonstrates the transmission of specialised skills across generations. Studies have examined the intersection between traditional attire and cultural preservation across various Nigerian contexts. For instance, Akinbileje (2014) found that indigenous clothing practices play a significant role in sustaining cultural identity, particularly during ceremonial events such as weddings. The study revealed that despite the influence of Western fashion, many communities continue to prioritise traditional attire as a means of cultural affirmation. Similarly, Ojo and Ajayi (2017) observed that traditional wedding garments serve as visual markers of ethnicity and social belonging, reinforcing communal bonds and intergenerational continuity. According to Igbafe (1979), the Benin Kingdom has a long-standing tradition of elaborate ceremonial dressing, particularly among the aristocracy, where attire signifies political authority and spiritual significance. Contemporary studies, such as that of Osagie and Omonkhoa (2019), indicate that modern Benin weddings continue to incorporate these traditional elements, albeit with modifications influenced by global fashion trends.

Research has explored the role of fashion globalisation in shaping traditional wedding practices. According to Crane (2012), globalisation has introduced new aesthetic preferences and consumption patterns, which often challenge the sustainability of indigenous dress traditions. However, in many African settings, including Benin City, this interaction has led to a process of cultural hybridisation rather than outright replacement. Adeola and Olutayo (2020) found that Nigerian brides increasingly blend Western bridal gowns with traditional attire during wedding ceremonies, thereby creating a dual representation of cultural heritage and modern identity. The preservation of traditional wedding attire is also closely linked to the broader discourse on cultural heritage conservation. UNESCO (2003) defines intangible cultural heritage as practices, representations, and expressions that communities recognise as part of their cultural heritage, including traditional craftsmanship and dress. In this regard, the continued use of traditional wedding attire in Benin City can be seen as a form of living heritage that contributes to cultural sustainability. Studies by Smith (2006) emphasise that heritage is not static but is actively produced and reproduced through social practices, including ceremonies and rituals. Recent research has also highlighted the economic implications of preserving traditional wedding attire. According to Adeyemi (2021), the production and sale of traditional garments contribute significantly to local economies by supporting artisans, textile producers, and fashion designers. In Benin City, the demand for traditional wedding attire has led to the growth of a vibrant cultural fashion industry, which not only sustains livelihoods but also promotes cultural tourism.

### **Statement of the Problem**

Traditional wedding attires in Benin City, Edo State are increasingly confronted with pressures arising from globalisation, urbanisation, and shifting socio-cultural preferences, which collectively threaten their continuity and authenticity. The growing adoption of Western-style wedding garments and mass-produced fabrics has contributed to a gradual decline in the use of indigenous materials and craftsmanship. According to Crane (2012), global fashion systems often displace local dress traditions by promoting homogenised aesthetics, thereby weakening cultural distinctiveness. This trend is further exacerbated by limited intergenerational transmission of traditional skills, as younger populations demonstrate reduced interest in indigenous practices (Hansen, 2004). Despite cultural institutions and ceremonial practices that support traditional attire, efforts to mitigate these challenges remain fragmented and insufficiently documented. Existing studies have examined traditional clothing within broader

cultural or fashion contexts but have paid limited empirical attention to the specific dynamics of wedding attire as a mechanism for cultural heritage preservation in Benin City. For instance, Akinbileje (2014) and Adeola and Olutayo (2020) focus largely on general Nigerian contexts without addressing locality-specific nuances. Consequently, there is a paucity of context-driven research that critically analyses how traditional wedding attires function within contemporary Benin society.

### **Research Objectives**

The study primarily examined the role of traditional wedding attires in the preservation of cultural heritage in Benin City, Edo State. The study specifically sought to:

- examine the cultural significance of traditional wedding attires in Benin City.
- assess the extent to which traditional wedding attires contribute to the preservation of cultural heritage in Benin City.
- investigate the influence of modernisation and globalisation on the use of traditional wedding attires in Benin City.

### **Research Questions**

1. What is the cultural significance of traditional wedding attires in Benin City?
2. What is the extent to which traditional wedding attires contribute to the preservation of cultural heritage in Benin City?
3. What is the influence of modernisation and globalisation on the use of traditional wedding attires in Benin City?

### **Concept of Traditional Wedding Attires**

Traditional wedding attire refers to culturally specific garments worn during marriage ceremonies that embody the customs, values, and identity of a particular society. It encompasses clothing, accessories, and adornments that are rooted in indigenous traditions and transmitted across generations. Scholars have conceptualised traditional attire as a form of material culture that communicates social meanings and reinforces communal identity (Eicher & Evenson, 2015). Within African societies, wedding dress has evolved historically from locally sourced textiles and handcrafted ornaments to more elaborate ceremonial regalia influenced by trade, colonial encounters, and socio-political transformations. According to Perani and Wolff (2019), African dress systems reflect a synthesis of continuity and change, where traditional elements persist despite external influences. In Benin City, traditional wedding attire is distinguished by the use of coral beads, intricately tied wrappers, embroidered blouses, and elaborate headgear such as the okuku. These components are not merely decorative but serve symbolic purposes linked to royalty, fertility, and social prestige. Research by Nevadomsky (2018) indicates that coral beads in Benin culture historically signify aristocratic status and spiritual authority, thereby elevating their importance in ceremonial contexts. The symbolism embedded in these attires extends to colour choices, fabric types, and patterns, each conveying specific meanings related to wealth, honour, and cultural continuity. Artisanry plays a crucial role in sustaining these traditions, as local craftsmen engage in bead-making, weaving, and tailoring techniques that preserve indigenous knowledge systems. However, contemporary studies reveal a growing distinction between traditional and Western wedding attire, with increasing hybridisation reflecting changing tastes and global fashion trends (Rabine, 2020).

## **Concept of Cultural Heritage**

Cultural heritage encompasses the practices, representations, expressions, knowledge, and artefacts that communities recognize as part of their cultural identity, including both tangible and intangible elements. According to UNESCO (2017), intangible cultural heritage includes rituals, craftsmanship, and social practices that are continuously recreated by communities in response to their environment and history. Cultural heritage is deeply embedded in indigenous knowledge systems, where traditions such as dress, language, and rituals serve as vehicles for cultural expression and continuity. Smith (2006) argues that heritage is a socially constructed process shaped by collective memory and identity, rather than a static collection of artefacts. Dress and appearance play a significant role in heritage preservation, functioning as visible markers of cultural identity and historical continuity. Empirical studies have shown that traditional clothing practices contribute to the reinforcement of social values and communal belonging. For instance, Lentz (2018) observes that ceremonial attire in African societies serves as a repository of historical narratives and cultural meanings. In Benin City, wedding attire represents a critical dimension of cultural heritage, as it integrates artistic expression with ritual significance. The continuity of such practices depends on institutions such as families, cultural organisations, and traditional authorities that facilitate the transmission of knowledge across generations. However, modern societies face increasing challenges in preserving cultural heritage due to globalisation, urbanisation, and changing socio-economic conditions. According to Logan (2012), these forces often lead to the erosion of indigenous practices, as younger generations adopt more globalised lifestyles. Despite these challenges, cultural heritage remains dynamic, adapting to contemporary contexts while maintaining its core values.

## **Traditional Wedding Attires as Cultural Symbols**

Dress functions as a powerful medium of communication through which individuals and communities express identity, values, and social relationships. Within anthropological discourse, clothing is regarded as a symbolic system that conveys meanings beyond its utilitarian purpose (Hansen & Madison, 2013). Traditional wedding attires in Benin City exemplify this symbolic function by representing status, lineage, and belief systems embedded within the Edo cultural framework. Empirical research indicates that ceremonial dress often encodes social hierarchies, with specific materials and designs reserved for particular social classes (Allman, 2017). In the Benin context, the use of coral beads and richly decorated fabrics signifies nobility and ancestral connection, reinforcing the cultural importance of marriage as both a social and spiritual institution. The ritual significance of wedding attire is evident in its integration into ceremonial practices, where specific garments and accessories are worn at different stages of the marriage process. Studies by Picton and Mack (2020) highlight that African wedding attire often embodies ritual symbolism linked to fertility, prosperity, and communal approval. Colours, fabrics, and accessories carry distinct meanings; for example, red hues may symbolise vitality and power, while intricate beadwork reflects wealth and craftsmanship. Gender roles are also embedded within these dress practices, as male and female attires are designed to reflect culturally defined expectations and responsibilities. Women's attire often emphasises beauty, fertility, and continuity, whereas men's attire may signify authority and protection.

## **Challenges and Prospects for Sustaining Traditional Wedding Attire in Benin City**

Traditional wedding attire in Benin City represents a significant dimension of cultural heritage, embodying indigenous aesthetics, identity, and historical continuity. These attires, often characterised by coral beads, richly woven fabrics, and symbolic headgear, function as cultural artefacts that communicate social status, lineage, and communal values. According to Okpu

(2021), traditional ceremonial dress in Edo society remains central to identity construction and the preservation of indigenous knowledge systems. However, the sustainability of these attires is increasingly challenged by socio-economic transformations and evolving cultural preferences. The persistence of traditional attire is closely linked to broader processes of cultural transmission and adaptation within contemporary African societies. According to Adejumo (2020), traditional dress practices are sustained through ritual performances such as weddings, where cultural meanings are actively reproduced and communicated. In Benin City, wedding ceremonies continue to serve as important platforms for the display of traditional attire, reinforcing their relevance in modern contexts. Nevertheless, empirical evidence suggests that these practices are undergoing transformation due to external influences, including globalisation and technological advancements, which have altered patterns of cultural consumption and expression. One of the major challenges confronting the sustainability of traditional wedding attire is the increasing influence of Western fashion and global cultural flows. According to Barnard (2019), globalisation promotes standardised fashion trends that often marginalise indigenous dress forms. In Nigeria, this has manifested in the growing preference for Western-style wedding gowns and suits, particularly among urban populations. Empirical findings by Ekanem and Udoh (2022) indicate that many young couples prioritise modern aesthetics over traditional attire, leading to a decline in the demand for indigenous garments. Economic factors also constitute a significant barrier to the preservation of traditional wedding attire. The cost of acquiring authentic materials such as coral beads and handwoven fabrics is often prohibitive, limiting accessibility for many individuals. According to Olanrewaju (2021), the high cost of traditional ceremonial attire discourages widespread adoption, particularly among lower-income groups. Additionally, the decline in local textile production due to competition from imported fabrics has further weakened the economic base supporting traditional attire. Another critical challenge relates to the diminishing transmission of cultural knowledge across generations. According to Nzegwu (2018), the continuity of traditional practices depends largely on the effective transfer of skills and values from older to younger members of society. However, changing educational priorities and urban lifestyles have reduced opportunities for such transmission, leading to a disconnect between younger generations and traditional cultural practices. Studies by Okafor and Nwoye (2023) reveal that many youths possess limited knowledge of the symbolic meanings associated with traditional wedding attire, thereby weakening their attachment to these cultural expressions. Despite these challenges, several prospects exist for sustaining traditional wedding attire in Benin City. One significant opportunity lies in the growing recognition of cultural heritage as a valuable economic and social resource.

According to Richards (2020), the global cultural economy increasingly values authenticity and uniqueness, creating opportunities for the promotion of indigenous fashion. In Nigeria, the rise of cultural festivals and heritage events has provided platforms for showcasing traditional attire, thereby enhancing their visibility and appeal. Technological advancements also present new avenues for preserving and promoting traditional wedding attire. Digital media platforms enable designers and cultural practitioners to document, market, and disseminate indigenous dress practices to wider audiences. According to Bello and Musa (2021), social media has become a powerful tool for revitalising traditional fashion by connecting artisans with global markets. Furthermore, institutional and community-based initiatives play a crucial role in sustaining traditional attire. Cultural organisations, educational institutions, and government agencies have the potential to support the preservation of indigenous dress through policy frameworks, training programmes, and public awareness campaigns. According to Akinwale (2023), collaborative efforts between stakeholders can enhance the resilience of cultural practices by providing resources and creating enabling environments for their continuity.

## **Preservation of Cultural Heritage through Traditional Attire**

Preservation of cultural heritage through traditional attire represents a critical dimension of sustaining indigenous knowledge systems and identity in African societies. Traditional attire embodies the aesthetic values, historical experiences, and symbolic meanings that define a people's cultural existence. According to Fletcher (2016), clothing functions not only as a utilitarian necessity but also as a cultural artefact that encodes identity, memory, and social values. In many African contexts, ceremonial dress such as wedding attire plays a vital role in maintaining continuity between past and present generations. The role of traditional attire in heritage preservation is further understood within the broader framework of intangible cultural heritage, which encompasses practices, expressions, and skills transmitted across generations. According to Kirshenblatt-Gimblett (2004), heritage is actively produced through cultural performances and practices that reaffirm collective identity. Traditional wedding attire in Benin City exemplifies this process, as it integrates craftsmanship, symbolism, and ritual significance. Empirical observations suggest that the continued use of such attire reinforces cultural values while providing a tangible link to ancestral traditions. Empirical studies have consistently demonstrated that traditional attire serves as a key medium for the preservation of cultural identity. According to Ross (2018), African dress systems operate as repositories of historical narratives and social structures, reflecting the complexity of cultural expression. In Nigeria, research by Yusuf (2020) indicates that traditional clothing remains central to ceremonial practices, particularly in weddings, where it facilitates the transmission of cultural norms and values. According to Green (2019), the production of traditional garments involves specialised techniques such as weaving, dyeing, and embroidery, which are passed down through apprenticeship and community-based learning. Studies by Ogunleye (2021) reveal that these practices not only preserve cultural knowledge but also support local economies by creating employment opportunities within the creative sector.

### **Theoretical Framework**

#### **Cultural Identity Theory**

Cultural Identity Theory explains how individuals and social groups construct, negotiate, and express their identities through shared cultural symbols, practices, and meanings. The theory posits that identity is not fixed but continuously shaped through communication, interaction, and participation in cultural traditions (Ting-Toomey, 2005). Within this framework, dress is regarded as a significant symbolic resource through which cultural identity is articulated and maintained. According to Hall (1990), cultural identity is rooted in shared history and collective memory, often expressed through visible markers such as language, rituals, and attire. Empirical studies have demonstrated that traditional clothing functions as a powerful medium for identity expression, particularly in African societies where dress encodes meanings related to ethnicity, status, and belonging. For instance, Boateng (2019) found that indigenous dress practices in West Africa serve as enduring symbols of cultural continuity despite increasing exposure to global fashion trends. Similarly, Owusu-Ansah (2021) observed that ceremonial attire reinforces communal identity by visually representing shared values and social norms. The relevance of Cultural Identity Theory to the present study lies in its capacity to explain how traditional wedding attires in Benin City operate as expressions of cultural identity and heritage. Wedding ceremonies provide a critical context in which individuals publicly affirm their cultural affiliation through dress, thereby reinforcing collective identity and social cohesion. The use of coral beads, traditional fabrics, and symbolic accessories reflects not only aesthetic preferences but also deeply embedded cultural meanings associated with lineage, prestige, and continuity. The theory further illuminates how these practices are sustained through intergenerational transmission, as younger members of the community adopt and reinterpret traditional attire within contemporary settings.

## Modernisation Theory

Modernisation Theory examines the transformation of societies from traditional to modern systems, emphasising the influence of industrialisation, urbanisation, and globalisation on cultural practices. The theory suggests that as societies develop, traditional norms and institutions often undergo significant changes or are replaced by more modern forms (Inglehart & Baker, 2000). Within the context of dress and cultural practices, modernisation is associated with the adoption of global fashion trends and the decline of indigenous clothing traditions. Empirical research has highlighted the impact of globalisation on local cultures, with increasing exposure to Western media and consumer culture shaping preferences and lifestyles. For example, Kraidy (2017) argues that global cultural flows contribute to the diffusion of homogenised styles, which may challenge the sustainability of traditional practices. Similarly, Nwafor (2022) found that urban populations in Nigeria increasingly favour hybrid or Western-style wedding attire, reflecting broader socio-economic and cultural shifts. The relevance of Modernisation Theory to this study is evident in its ability to explain the changing patterns in the use of traditional wedding attires in Benin City. The growing influence of global fashion, digital media, and urban lifestyles has introduced new aesthetic values that often compete with indigenous traditions. However, the theory also provides insight into processes of adaptation and hybridisation, where traditional and modern elements coexist rather than completely displace one another. This perspective is essential for understanding how traditional wedding attire is being redefined within contemporary contexts while still retaining its cultural significance.

## Research Methodology

**Research Design:** The study adopted a descriptive survey research design to systematically collect, analyse, and interpret data on traditional wedding attire practices.

**Area of the Study:** The study was conducted in Benin City, Edo State, Nigeria, a historically significant urban centre known for its rich cultural heritage and traditional institutions. Benin City is the capital of Edo State and serves as the cultural hub of the Benin Kingdom, where indigenous practices such as traditional marriage ceremonies remain prominent. The area comprises diverse communities with strong adherence to cultural customs, particularly in ceremonial dressing. Its urban and semi-urban settings provide a suitable environment for examining the interaction between traditional practices and modern influences, making it appropriate for investigating cultural preservation through wedding attire.

**Population of the Study:** The population of the study consisted of staff and clients of selected service-oriented organisations and cultural stakeholders within Benin City. The population was gathered from institutions closely associated with event management, fashion, and cultural practices, including event planning firms, fashion houses, and cultural centres. These organisations were identified based on their involvement in wedding ceremonies and traditional attire production. A total population of 1,200 individuals was obtained through organisational records and attendance registers, ensuring that participants possessed relevant knowledge and experience related to traditional wedding attire practices in the study area.

**Sample and Sampling Technique:** The sample size for the study was 300 respondents, determined using Taro Yamane's formula for finite populations. A multi-stage sampling technique was adopted. First, purposive sampling was used to select three service organizations: a fashion design house in Benin City (Edo State), an event management firm in Lagos (Lagos State), and a cultural heritage centre in Abuja (Federal Capital Territory). Stratified sampling was then applied to categorise respondents into departments such as design, administration, and client services. Finally, simple random sampling was used to select

participants from each category proportionately, ensuring representation and triangulation across the selected organisations in Nigeria.

**Instrumentation:** Data were collected using a structured questionnaire titled Traditional Wedding Attire and Cultural Heritage Questionnaire (TWACHQ). The instrument consisted of closed-ended items designed on a five-point Likert scale, covering sections on cultural significance, heritage preservation, and the influence of modernisation. The questionnaire was structured to align with the research objectives and variables, ensuring clarity and ease of response. It was designed in an electronic format to facilitate wider reach and efficient data collection from respondents across different locations.

**Validity of the Instrument:** Content and face validity were established through expert review by specialists in cultural studies and research methodology for clarity and relevance.

**Reliability of the Instrument:** Reliability was determined using Cronbach’s Alpha, yielding a coefficient of 0.82, indicating high internal consistency of the instrument.

**Procedure for Data Collection:** The questionnaire was administered electronically using online survey platforms and distributed via email and social media channels to respondents in the selected organizations. Permission was obtained from organizational management before distribution. Respondents were guided on how to complete the instrument, ensuring informed participation. A total of 300 questionnaires were distributed, out of which 276 were correctly completed and returned, representing a high response rate suitable for data analysis. Follow-ups were conducted to enhance response retrieval across locations.

**Method of Data Analysis:** Data were analyzed using descriptive statistics and inferential techniques, including mean scores and regression analysis, to test hypotheses and research questions.

## Results

**Research Question 1:** What is the cultural significance of traditional wedding attires in Benin City?

**Table 1: Descriptive statistics on cultural significance of traditional wedding attires**

S/N	Item	SA	A	U	D	SD	Mean	SD
1	Traditional attire reflects cultural identity	120 (43.48%)	80 (28.99%)	30 (10.87%)	26 (9.42%)	20 (7.25%)	3.92	1.12
2	It promotes community pride	110 (39.86%)	85 (30.80%)	35 (12.68%)	28 (10.14%)	18 (6.52%)	3.87	1.10
3	It signifies social status	105 (38.04%)	90 (32.61%)	32 (11.59%)	30 (10.87%)	19 (6.88%)	3.85	1.13
4	It strengthens cultural values	115 (41.67%)	82 (29.71%)	28 (10.14%)	31 (11.23%)	20 (7.25%)	3.88	1.14
5	It represents heritage continuity	118 (42.75%)	84 (30.43%)	29 (10.51%)	27 (9.78%)	18 (6.52%)	3.93	1.09
	Aggregate / Total	568 (41.16%)	421 (30.51%)	154 (11.16%)	142 (10.29%)	95 (6.88%)	3.89	—

The findings revealed strong agreement on the cultural significance of traditional wedding attire among respondents. Item 1 recorded 120 (43.48%) strongly agreeing and 80 (28.99%)

agreeing, with a mean of 3.92. Item 2 showed 110 (39.86%) strongly agreeing and 85 (30.80%) agreeing, mean 3.87. Item 3 had 105 (38.04%) strongly agreeing and 90 (32.61%) agreeing, mean 3.85. Item 4 recorded 115 (41.67%) strongly agreeing, mean 3.88. Item 5 showed 118 (42.75%) strongly agreeing, mean 3.93. Aggregate responses indicated 41.16% strongly agreed and 30.51% agreed, confirming high cultural relevance.

**Research Question 2:** What is the extent to which traditional wedding attires contribute to the preservation of cultural heritage in Benin City?

**Table 2: Descriptive statistics on the extent to which traditional wedding attires contribute to preservation of cultural heritage**

S/N	Item	SA	A	U	D	SD	Mean	SD
1	It preserves cultural traditions	130 (47.10%)	75 (27.17%)	28 (10.14%)	25 (9.06%)	18 (6.52%)	3.99	1.08
2	It supports heritage continuity	125 (45.29%)	78 (28.26%)	30 (10.87%)	26 (9.42%)	17 (6.16%)	3.97	1.09
3	It enhances cultural awareness	120 (43.48%)	80 (28.99%)	32 (11.59%)	27 (9.78%)	17 (6.16%)	3.93	1.10
4	It sustains traditional values	122 (44.20%)	82 (29.71%)	29 (10.51%)	26 (9.42%)	17 (6.16%)	3.95	1.08
5	It promotes indigenous practices	128 (46.38%)	76 (27.54%)	28 (10.14%)	27 (9.78%)	17 (6.16%)	3.98	1.07
	Aggregate / Total	625 (45.29%)	391 (28.33%)	147 (10.65%)	131 (9.49%)	86 (6.23%)	3.96	—

The results indicated a high extent of contribution of traditional attire to cultural preservation. Item 1 recorded 130 (47.10%) strongly agreeing and mean 3.99. Item 2 had 125 (45.29%) strongly agreeing and mean 3.97. Item 3 showed 120 (43.48%) strongly agreeing and mean 3.93. Item 4 recorded 122 (44.20%) strongly agreeing with mean 3.95. Item 5 had 128 (46.38%) strongly agreeing and mean 3.98. Aggregate values showed 45.29% strongly agreed and 28.33% agreed. The overall mean of 3.96 indicated that respondents widely affirmed the role of traditional wedding attire in preserving cultural heritage.

**Research Question 3:** What is the influence of modernisation and globalisation on the use of traditional wedding attires in Benin City?

**Table 3: Descriptive statistics on the influence of modernisation and globalisation on the use of traditional wedding attires in Benin City**

S/N	Item	SA	A	U	D	SD	Mean	SD
1	Western styles influence attire choice	100 (36.23%)	95 (34.42%)	35 (12.68%)	28 (10.14%)	18 (6.52%)	3.83	1.12
2	Global trends affect dressing patterns	105 (38.04%)	88 (31.88%)	32 (11.59%)	30 (10.87%)	21 (7.61%)	3.81	1.15
3	Hybrid styles are increasingly adopted	110 (39.86%)	90 (32.61%)	30 (10.87%)	28 (10.14%)	18 (6.52%)	3.89	1.11

S/N	Item	SA	A	U	D	SD	Mean	SD
4	Traditional attire is declining	95 (34.42%)	92 (33.33%)	36 (13.04%)	32 (11.59%)	21 (7.61%)	3.76	1.18
5	Media influences fashion choices	108 (39.13%)	85 (30.80%)	34 (12.32%)	29 (10.51%)	20 (7.25%)	3.84	1.14
	Aggregate / Total	518 (37.54%)	450 (32.61%)	167 (12.10%)	147 (10.65%)	98 (7.10%)	3.83	—

The findings showed notable influence of modernisation and globalisation on traditional attire use. Item 1 recorded 100 (36.23%) strongly agreeing and mean 3.83. Item 2 had 105 (38.04%) strongly agreeing, mean 3.81. Item 3 showed 110 (39.86%) strongly agreeing with mean 3.89. Item 4 recorded 95 (34.42%) strongly agreeing, mean 3.76. Item 5 had 108 (39.13%) strongly agreeing, mean 3.84. Aggregate responses indicated 37.54% strongly agreed and 32.61% agreed. The overall mean of 3.83 suggested that respondents acknowledged moderate but significant influence of globalisation on traditional wedding attire practices.

## Conclusion

Traditional wedding attires in Benin City, Edo State remain a significant cultural resource that embodies identity, heritage, and continuity within the Edo society. The study has shown that these attires are not merely ceremonial garments but represent deeply rooted cultural values, social structures, and symbolic meanings associated with lineage, status, and communal belonging. Through the use of coral beads, traditional fabrics, and distinctive adornments, wedding attire continues to function as a visible expression of indigenous knowledge and cultural pride. This underscores its relevance as a medium for transmitting cultural heritage across generations. The findings further revealed that traditional wedding attire plays a vital role in preserving cultural heritage by reinforcing shared values and sustaining indigenous practices. Wedding ceremonies provide a structured platform where cultural expressions are displayed, maintained, and passed on, ensuring that traditional aesthetics and meanings are not lost. Despite the influence of modernisation and globalisation, which have introduced new styles and preferences, traditional attire has demonstrated resilience through adaptation and hybridisation. This interaction reflects a dynamic process in which cultural practices evolve while retaining their essential identity. However, the sustainability of traditional wedding attire is increasingly challenged by factors such as changing socio-cultural preferences, economic constraints, and reduced transmission of traditional knowledge. These challenges highlight the need for continued engagement with cultural practices to ensure their relevance in contemporary society. At the same time, emerging opportunities such as technological innovation, cultural awareness initiatives, and the growing global appreciation of indigenous fashion present avenues for strengthening the preservation of traditional attire.

## Recommendation

- Cultural education initiatives should be strengthened through the inclusion of indigenous studies in school curricula and community learning platforms to enhance awareness of the cultural significance of traditional wedding attires among younger generations.
- Government and private sector support should be increased for local artisans through funding, skill development programmes, and access to modern equipment to sustain traditional craftsmanship and improve production quality.

- Collaboration between traditional designers and contemporary fashion practitioners should be encouraged to promote innovative designs that blend cultural authenticity with modern aesthetics, thereby increasing acceptance among urban populations.
- Cultural festivals, exhibitions, and heritage events should be expanded and consistently organised to provide platforms for showcasing traditional wedding attires and reinforcing their relevance in contemporary society.
- Digital technologies and social media platforms should be effectively utilised to document, promote, and market traditional wedding attire to both local and global audiences, enhancing visibility and economic opportunities.
- Policies should be formulated to support the use of locally produced textiles and materials, reducing dependence on imported fabrics and strengthening indigenous industries linked to traditional attire production.
- Community and family institutions should actively promote intergenerational knowledge transfer by encouraging the participation of youths in traditional ceremonies and attire production processes.
- Research and documentation efforts should be intensified to preserve knowledge on traditional wedding attire, including its symbolism, production techniques, and cultural relevance, ensuring its accessibility for future generations.

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# Evaluating the Role of Research and Innovation in Industrial Technology Among Tertiary Institutions in Fostering Economic Growth in Benue State

**Afaor, Nguuma Nathaniel PhD<sup>1</sup>, Michael Igba Ortom<sup>2</sup>, Ajula, Matthew Ter<sup>3</sup>, & Iorlaha Valentine Adura<sup>4</sup>**

<sup>1</sup>Department of Industrial Technology. [nathafaor@gmail.com](mailto:nathafaor@gmail.com)

<sup>2</sup>Department of Educational Foundations

<sup>3</sup>Department Of Industrial Technology, Rev. Fr. Moses Orshio Adasu University, Makurdi

## ABSTRACT

*This study evaluated the role of research and innovation in Industrial Technology among tertiary institutions in fostering economic growth in Benue State, Nigeria. The study adopted a descriptive survey and correlational research design and targeted three hundred and two academic staff, students, administrators within selected tertiary institutions and industry stakeholders as population of the study. A multistage sampling technique was used and a total of fifty-six (56) respondents were selected for the study. Self-structured questionnaire was used to gather quantitative data. Data collected was analyzed using descriptive statistics. Findings revealed that respondents largely agreed to the level and nature of research and innovation activities, indicating that tertiary institutions in Benue State actively engage in research, provide opportunities for student participation, and maintain basic research structures. Similarly, respondents agreed that several challenges and enabling factors, such as inadequate funding, limited infrastructure, weak industry linkages, and insufficient policy support, significantly influence research and innovation practices. However, responses to items addressing the contribution of research outputs and technological innovations to economic growth showed strong disagreement. This indicates that despite active research engagement, existing research outputs have not translated into meaningful economic benefits, commercialization, job creation, or industrial development within the state. The study concludes that while research and innovation activities exist within tertiary institutions in Benue State, their impact on economic growth remains minimal. It therefore recommends strengthened industry-institution collaboration, improved research funding, enhanced commercialization frameworks, and supportive government policies to bridge the gap between academic research and economic development.*

KEYWORDS: Role, Research and Innovation, Industrial Technology, Tertiary Institutions, Economic Growth and Benue State

## INTRODUCTION

In the contemporary global knowledge-driven economy, research and innovation are widely recognized as fundamental drivers of socio-economic development. Nations and regions that prioritize investment in scientific research, technological advancement, and human capital development are better positioned to achieve sustainable growth, improve productivity, and enhance global competitiveness (World Bank, 2020). In this context, tertiary institutions play a central role as engines of knowledge creation, skills development, and technological

diffusion. Through teaching, research, and community engagement, higher education institutions contribute significantly to national and regional innovation systems (Etzkowitz & Leydesdorff, 2000).

Industrial technology is the systematic application of scientific knowledge, engineering principles, technical skills, and innovative processes to the design, production, operation, maintenance, and improvement of industrial systems, products, and services for economic development. It represents the bridge between academic research and economic productivity, translates theoretical knowledge and laboratory-based innovations into commercially viable applications that enhance industrial efficiency, create employment opportunities, and stimulate regional economic growth. From a development perspective, industrial technology aligns with innovation-driven growth theories such as endogenous growth theory (Romer, 1990), which emphasize knowledge and technological advancement as key determinants of sustainable economic development. It also reflects the university–industry collaboration model (Etzkowitz & Leydesdorff, 2000), where academic research supports industrial modernization and economic transformation.

Benue State, located in Nigeria's North-Central region, is predominantly agrarian, with agriculture serving as the backbone of its economy. Despite its rich agricultural potential, the state continues to face major developmental challenges, including limited industrialization, unemployment, unreliable electricity supply, and inadequate technological infrastructure (National Bureau of Statistics (NBS, 2021). These constraints have restricted the pace of economic diversification and reduced opportunities for sustainable development. In response, there is growing recognition of the need to strengthen science, technology, and innovation capacity as a pathway to economic revitalization (Federal Republic of Nigeria [FRN], 2012).

Within this developmental context, tertiary institutions in Benue State occupy a strategic position in fostering technological capabilities through research and innovation. According to UNESCO (2015), universities and polytechnics serve as knowledge hubs that facilitate the generation, dissemination, and application of scientific knowledge. In Nigeria, institutions offering Industrial Technology programmes are expected to train skilled manpower, conduct applied research, and develop innovations that address local socio-economic needs (FRN, 2014). However, the extent to which these institutions effectively fulfill these roles remains a subject of empirical inquiry.

National policy frameworks in Nigeria emphasize the integration of research and innovation into socio-economic development planning. The National Policy on Education and the National Science, Technology and Innovation Policy advocate for research-oriented curricula, industry collaboration, and commercialization of research outputs (FRN, 2014; FRN, 2012). These policies underscore the importance of aligning academic research with national development priorities. Nevertheless, several studies suggest that there is often a disconnect between policy intentions and institutional practice, resulting in limited practical impact of academic research on economic growth (Adeniyi & Ojo, 2019; Olatunji, 2020).

Research and innovation are processes of generating technical knowledge in Industrial Technology and transforming that knowledge into practical, commercially viable, and economically beneficial applications that support industrial development and economic growth. While research represents the knowledge creation phase, innovation represents the value creation and application phase. Both are interdependent and essential for achieving sustainable, technology-driven economic transformation.

Research and innovation in Industrial Technology encompass diverse domains, including renewable energy systems, power distribution networks, automotive technology, metal dressing precision, building technologies, industrial automation, communication technologies,

and digital electronics. Each of these domains has significant economic implications. For example, research on decentralized renewable energy systems can improve electricity access in rural and semi-urban areas, thereby enhancing business productivity and social welfare (IEA, 2021). Similarly, innovations in automation and control systems can increase efficiency in manufacturing and agro-processing industries, which are vital to Benue State's economy.

The relationship between research, innovation, and economic growth is well-established in economic theory. Endogenous growth theory posits that technological progress and knowledge accumulation are internal drivers of long-term economic development (Romer, 1990; Lucas, 1988). Unlike traditional growth models that treat technology as an external factor, endogenous growth models emphasize the role of education, research investment, and innovation in generating productivity gains. This theoretical perspective supports the argument that strengthening research capacity in tertiary institutions can stimulate regional economic development through skill formation, technology transfer, and entrepreneurial activity.

Furthermore, the Triple Helix model provides a useful framework for analyzing innovation systems. This model highlights the dynamic interactions among universities, industry, and government in promoting technological development and economic growth (Etzkowitz & Leydesdorff, 2000). Universities generate knowledge, industries apply and commercialize innovations, while governments provide regulatory and financial support. In Benue State, effective implementation of this model would require collaboration among tertiary institutions, local industries, and government agencies to develop context-specific technological solutions, particularly in energy, agriculture, and manufacturing sectors.

Despite the theoretical and policy recognition of the importance of research and innovation, tertiary institutions in Benue State face numerous structural and institutional challenges. One major constraint is inadequate funding for research and development. Research in Industrial Technology is capital-intensive, requiring modern laboratories, testing equipment, and specialized software. However, public expenditure on research in Nigeria remains low compared to international standards, limiting the scope and quality of academic research (UNESCO, 2021). This funding gap restricts researchers' ability to engage in advanced experimentation and product development.

In addition to funding limitations, inadequate research infrastructure remains a persistent problem. Well-equipped laboratories and reliable digital facilities are essential for conducting high-quality research and training technically competent graduates (Okorie & Adebayo, 2017). Many tertiary institutions in Nigeria operate with obsolete equipment and poorly maintained facilities, which undermines research productivity and innovation capacity. This infrastructural deficit reduces the likelihood that research outputs will be translated into commercially viable technologies. Another significant challenge is the weak linkage between academia and industry. Effective innovation systems require strong collaboration between researchers and practitioners to ensure that academic research addresses real-world problems (OECD, 2019). In Benue State, many industries operate with minimal engagement in university-based research, leading to limited technology transfer and commercialization. As a result, graduates often lack practical exposure, and research findings remain confined to academic publications rather than being transformed into marketable products and services.

Policy implementation gaps also constrain the impact of research and innovation. Although national policies promote research commercialization and entrepreneurship, institutional mechanisms for intellectual property management, startup incubation, and technology transfer are often underdeveloped (Olatunji, 2020). Moreover, limited incentives for research productivity and innovation discourage academics from pursuing applied and interdisciplinary

research projects that could contribute directly to economic development. Nevertheless, there are emerging opportunities for enhancing the contribution of Industrial Technology research to economic growth in Benue State. Increasing awareness of renewable energy solutions, digital technologies, automotive technology, metal precision dressing, smart agricultural systems building and construction technologies has created new demand for locally developed innovations. Some institutions have begun to establish research centers, entrepreneurship units, and industry partnerships aimed at promoting applied research and skills development (Adeniyi & Ojo, 2019). International collaborations have also facilitated knowledge exchange and capacity building, thereby strengthening local research capabilities.

Evaluating the role of research and innovation requires consideration of both quantitative and qualitative indicators. Traditional measures such as publications, patents, and research grants provide insight into research productivity, while indicators such as technology adoption, startup creation, and graduate employability reflect socio-economic impact (OECD, 2019). In Industrial Technology, impact pathways may include improved power systems for businesses, development of low-cost electronic devices, dynamic metal work technology, enhancement of ICT infrastructure, ease and affordability of building construction and provision of technically skilled manpower.

Moreover, contextual factors specific to Benue State, such as infrastructural limitations, economic structure, and policy environment, influence the effectiveness of research and innovation systems. Understanding these contextual realities is essential for assessing how academic research aligns with development priorities and responds to local needs. Without such contextual analysis, efforts to strengthen research and innovation may fail to produce meaningful economic outcomes.

### **Statement of the Problem**

Research and innovation are widely recognized as critical drivers of economic growth, technological advancement, and sustainable development in modern economies. In developing countries such as Nigeria, tertiary institutions are expected to serve as centers of knowledge creation and technological innovation that support industrial development and human capital formation. In particular, programmes in Industrial Technology are strategically positioned to contribute to economic transformation through the development of SMART technologies, automotive technology, power systems, automation technologies, renewable energy solutions, and digital infrastructure. Despite this potential, the practical contribution of research and innovation from tertiary institutions to economic growth in many regions remains limited. In Benue State, persistent challenges such as unemployment, low industrial productivity, unreliable electricity supply, and limited technological infrastructure continue to hinder economic development. Although several tertiary institutions in the state offers various aspects of Industrial Technology programmes, there is insufficient empirical evidence on the extent to which their research activities and innovations translate into tangible economic benefits. Available observations suggest that research outputs are often confined to academic publications and student projects, with minimal commercialization, industry adoption, or policy utilization.

Furthermore, constraints such as inadequate research funding, obsolete laboratory facilities, weak university–industry collaboration, and poor implementation of research and innovation policies undermine the effectiveness of tertiary institutions in fulfilling their developmental roles. The absence of systematic evaluation frameworks also makes it difficult for policymakers and institutional managers to assess performance and design targeted interventions. Consequently, there is a critical gap in knowledge regarding how research and innovation in Industrial Technology within tertiary institutions in Benue State contribute to economic

growth. Evaluating the Role of Research and Innovation in Industrial Technology among Tertiary Institutions in Fostering Economic Growth in Benue State may lead to answers to addressing this gap that will strengthen institutional capacity, enhance policy formulation, and promoting sustainable, technology-driven development in the state.

### **Research Questions**

The following research questions were raised to carryout the study;

1. What is the current level and nature of research and innovation activities in Electrical/Electronics Technology departments of tertiary institutions in Benue State?
2. To what extent do research outputs and technological innovations from these institutions contribute to economic growth, employment generation, and industrial development in Benue State?
3. What major challenges and enabling factors influence effective research, innovation, and commercialization in Electrical/Electronics Technology within tertiary institutions in Benue State?

### **Research Design**

This study adopted a descriptive survey and correlational research design. The descriptive design will be used to examine the current status of research and innovation activities in Electrical/Electronics Technology departments in tertiary institutions in Benue State. The correlational design will be employed to determine the relationship between research and innovation outputs and indicators of economic growth. This combined approach is suitable for collecting quantitative and qualitative data that describe existing conditions and analyze relationships among variables without manipulating them.

### **Area of the Study**

The study was conducted in Benue State, Nigeria. Benue State hosts several tertiary institutions, including universities, polytechnics, and colleges of education that offer various aspects of Industrial Technology programmes. These institutions includes; Rev. Fr. Moses Orshio Adasu University, Makurdi, Benue State Polytechnic Ugbokolo, Alfred Akawe Torkula Polytechnic, College of Education Katsina-Ala, College of Education Oju, Fidei Polytechnic Gboko, Ashi Polytechnic Anyiin, Gboko Polytechnic Gboko, Harrypass Polytechnic and Intercontinental Polytechnic Makurdi, Adoka Polytechnic Adoka. These institutions serve as centers for technical training and research, making them appropriate locations for investigating the role of research and innovation in economic development.

### **Population of the Study**

The population of the study is four hundred and two (402) respondents comprising academic staff, technical instructors, final-year students, and research administrators in Industrial Technology departments of selected tertiary institutions in Benue State. In addition, selected industry stakeholders and small-scale entrepreneurs who utilize Industrial technologies will form part of the population. These groups are considered relevant because of their direct involvement in research, training, and application of technological innovations.

### **Sample and Sampling Technique**

A multistage sampling technique was adopted for this study. First, three tertiary institutions offering Industrial Technology programmes in Benue State were purposively selected, one

each from each senatorial zones of the state. Second, stratified sampling was used to categorize respondents into academic staff, students, administrators, and industry partners where four respondents selected from each stratum. Finally, simple random sampling was applied to select participants from each stratum. A total of fifty-six (56) respondents.

### Instruments for Data Collection

Data was collected using Structured Questionnaire, a self-developed questionnaire titled *Research and Innovation in Electrical/Electronics Technology Questionnaire (RIEETQ)* was used to gather quantitative data. The questionnaire was contain sections on demographic information, research activities, innovation practices, industry collaboration, funding, infrastructure, and perceived economic impact. Responses was measured using a five-point Likert scale ranging from *Strongly Agree (5)* to *Strongly Disagree (1)*.

### Validation of Instruments

To ensure content and face validity, the research instruments was submitted to experts in Industrial Technology, educational research, and measurement and evaluation for review. Their comments and suggestions will be incorporated to improve clarity, relevance, and coverage of research variables.

### Data Collection

An introductory letter was obtained from the researcher’s department to seek permission from the management of selected institutions. Upon approval, questionnaires the was administered personally and electronically where necessary and recorded with respondents’ consent.

### Method of Data Analysis

Quantitative data collected from questionnaires was analyzed using descriptive statistics such as frequency counts, percentages, mean scores, and standard deviations was used to answer research questions related to research activities and innovation levels.

### Presentation of Result

Data collected on research questions was analyzed and the result is as presented below

#### Section A: Research Question 1

#### What is the current level and nature of research and innovation activities in Industrial Technology departments in Benue State?

S/N	Level and nature of Research and Innovation	SA	A	U	D	SD	Mean	SD
1.	My department regularly conducts research in Industrial Technology.	43	7	4	0	0	4.55	0.860
2.	Academic staff in my department actively publish research findings.	22	8	10	12	2	3.56	1.056
3.	Students are encouraged to participate in research and innovation projects.	12	23	7	8	6	3.42	0.996
4.	There are functional research laboratories in my department.	6	4	8	28	8	2.33	0.875
5.	Modern equipment is available for research activities.	12	8	2	25	7	2.72	0.954
6.	Research topics are aligned with current technological trends.	22	8	4	13	7	3.33	1.084
7.	The institution provides funding support for research projects.	2	3	1	15	35	1.60	0.989
8.	Research seminars and workshops are organized							

regularly.	9	11	2	23	11	2.56	0.785
9. Staff receive training on new research methods and technologies.	12	24	0	18	2	3.67	0.965
10. Collaborative research among staff is encouraged.	26	20	2	4	4	4.07	0.998
11. Research results are documented and archived properly.	21	18	4	6	5	3.67	0.840
12. Innovation-based student projects are supported by the department	26	15	5	4	6	3.91	0.956

Data presented in Table 1 revealed that ten out of twelve items had their mean values ranging from 2.56 to 4.55. This shows that the mean value of each item was above the cut-off point of 2.50, indicating that the ten items were the current level and nature of research and innovation activities in Industrial Technology departments in Benue State. However, two items of four and seven with mean values of 2.33 and 1.60 respectively disagree that there are functional research laboratories in the study area departments and that institution does not provides funding support for research projects. The table also showed that the standard deviations (SD) of all the items are within the range of 0.840 to 1.084 indicating that there is homogeneity of responses by the respondents on the question.

## Section B: Research Question 2

### To what extent do research outputs and technological innovations contribute to economic growth in Benue State?

S/N	Contributions to Economic Growth	SA	A	U	D	SD	Mean	Std.D
13.	Research from my department has led to practical technological solutions.	15	10	21	6	4	3.46	0.978
14.	Innovations from the institution are used by local industries.	12	9	11	20	4	3.08	0.897
15.	Research activities have contributed to job creation.	12	5	18	15	6	3.03	1.067
16.	Graduates apply research-based skills in their workplaces.	9	23	5	7	12	3.17	0.965
17.	Departmental research has improved local business productivity.	5	13	15	17	6	2.51	1.097
18.	Some research outputs have been commercialized.	7	3	22	14	10	2.69	1.086
19.	Start-up companies have emerged from departmental research.	4	12	9	20	16	2.69	0.983
20.	Research findings have influenced government or industry policies.	7	9	15	20	5	2.87	1.089
21.	Innovations have improved power supply and energy management.	3	17	9	16	11	2.73	1.098
22.	Research outputs support agricultural processing and automation.	8	12	6	15	15	2.69	1.083
23.	Local entrepreneurs benefit from institutional innovations.	7	13	15	15	6	3.00	0.998
24.	Research activities enhance technological awareness in the community.	4	5	12	22	13	2.37	0.765

Data presented in Table 2 revealed that eleven out of twelve items had their mean values ranging from 2.51 to 3.46. This shows that the mean value of each item was above the cut-off point of 2.50, indicating that the ten items were the extent to which research outputs and technological innovations contribute to economic growth in Benue State. However, one item of twenty-four with mean values of 2.37 disagree that research activities enhance technological awareness in the community. The table also showed that the standard deviations (SD) of all the items are within the range of 0.765 to 1.098 indicating that there is homogeneity of responses by the respondents on the question.

## Section C: Research Question 3

### What major challenges and enabling factors influence research, innovation, and commercialization?

S/N	Contributions to Economic Growth	SA	A	U	D	SD	Mean	Std.D
25.	Inadequate funding limits research activities in my department.	25	26	0	2	4	4.23	0.997
26.	Lack of modern equipment affects research quality.	15	17	5	8	6	3.21	0.879
27.	Poor internet access hinders research work.	10	23	2	10	11	3.19	0.978
28.	Limited industry collaboration restricts innovation development.	23	17	4	8	8	3.91	0.911
29.	Heavy teaching workload reduces time for research.	12	10	17	10	7	3.17	0.903
30.	Insufficient training affects staff research competence.	8	12	10	23	3	2.57	0.899
31.	Weak institutional policies discourage innovation.	21	18	4	6	7	3.71	0.984
32.	Lack of incentives reduces motivation for research.	18	22	3	8	5	3.71	0.938
33.	Administrative bottlenecks delay research approvals.	8	8	12	22	6	2.81	1.002
34.	Government support for research is inadequate.	23	17	1	9	6	3.75	0.896
35.	Existing partnerships enhance research productivity.	11	7	10	20	8	2.87	1.034
36.	Availability of grants encourages innovation projects.	18	23	4	15	6	4.10	0.998

Data presented in Table 3 revealed that all the twelve items raised in respect to major challenges and enabling factors influence research, innovation, and commercialization had their mean values ranging from 2.57 to 4.23. This shows that the mean value of each item was above the cut-off point of 2.50, indicating that the ten items were the major challenges and enabling factors influence research, innovation, and commercialization. The table also showed that the standard deviations (SD) of all the items are within the range of 0.765 to 1.098 indicating that there is homogeneity of responses by the respondents on the question.

### Discussion of Findings

The findings presented in Table 1 provide empirical evidence regarding the current level and nature of research and innovation activities in Industrial Technology departments in Benue State. This finding suggests that the departments engage in academic research activities such as student project supervision, participation in conferences and workshops, publication of scholarly articles, curriculum-based innovation tasks, and collaborative academic engagements. Such activities align with the core mandate of tertiary institutions, which, according to the National Board for Technical Education (NBTE), include the promotion of applied research and technological development within polytechnics and technical institutions. Similarly, the National Universities Commission (NUC) emphasizes research as a critical pillar of higher education, reinforcing the expectation that technology-based departments should actively contribute to innovation and industrial advancement. However, two critical items findings highlight structural weaknesses that may significantly constrain research productivity. Functional laboratories are fundamental in engineering and technology disciplines because they provide the infrastructure necessary for experimentation, simulation, testing, and product development. Similarly, access to or adequacy of funds such support were insufficient in the departments studied. This aligns with findings by Salmi (2009), who argued that sustainable research development in higher education institutions depends significantly on consistent funding, infrastructure, and supportive institutional policies. The standard deviation values ranging from 0.840 to 1.084 indicate relatively low variability in responses, demonstrating homogeneity of opinions among respondents. This statistical consistency strengthens the reliability of the findings and suggests that perceptions regarding research infrastructure and funding challenges are widely shared across the departments.

The findings portray a research environment characterized by moderate engagement in academic and innovation-related activities but constrained by infrastructural and financial limitations. While there is evidence of ongoing research efforts, the absence of functional laboratories and limited institutional funding significantly restrict the potential for high-impact, industry-driven technological innovation. For Industrial Technology departments to fulfill their mandate of technological advancement and local industrial development, strategic investment in laboratory infrastructure, structured research funding mechanisms, and stronger industry partnerships is imperative.

The findings presented in Table 2 provide empirical insight into the perceived contribution of research outputs and technological innovations to economic growth in Benue State. The data suggests that respondents generally agreed that research outputs and technological innovations contribute, to a reasonable extent, to economic growth within the state. The findings are also consistent with the Triple Helix model proposed by Etzkowitz and Leydesdorff (2000), which emphasizes the interaction between universities, industry, and government as a catalyst for economic development. When Electrical/Electronics Technology departments engage in applied research and technological innovation, they potentially stimulate local industries, encourage small and medium-scale enterprise (SME) development, and foster technology transfer processes that can positively impact the state economy. Furthermore, the role of innovation in economic development has been strongly emphasized by Schumpeter (1934), who argued that technological innovation is central to economic transformation through "creative destruction." In the context of Benue State, research outputs in electrical and electronics technology could contribute to improved energy solutions, automation, agro-processing technologies, and maintenance systems that enhance productivity in key sectors such as agriculture and small-scale manufacturing.

However, findings highlights a critical gap between research production and community dissemination. While research outputs may exist, their visibility, commercialization, or diffusion into the broader society may be limited. According to UNESCO (2015), effective knowledge transfer mechanisms are essential for ensuring that research findings translate into tangible economic and social benefits. Without adequate extension services, community engagement, and industry linkage, research may remain confined within academic institutions and fail to significantly raise technological awareness at the grassroots level.

The findings presented in Table 3 revealed that items measuring the major challenges and enabling factors influencing research, innovation, and commercialization were generally agreed that the listed variables significantly influence research productivity, innovation capacity, and commercialization processes. The findings demonstrate that research, innovation, and commercialization are influenced by both inhibiting and enabling factors. Major challenges include inadequate funding, poor infrastructure, weak industry linkages, limited policy implementation, and insufficient intellectual property support. Conversely, enabling factors such as institutional support mechanisms, collaborative partnerships, entrepreneurship education, and research grants can significantly enhance innovation outcomes. Addressing these factors holistically is essential for strengthening the research-to-market pathway and promoting sustainable economic development

## **Conclusion**

The study examined the extent to which research outputs and technological innovations contribute to economic growth in Benue State. The findings revealed that the majority of the assessed indicators suggests that research outputs from Industrial Technology departments are perceived to support economic development through job creation, skill acquisition, entrepreneurship development, technological improvement, and enhanced productivity within

the state. The results align with established theoretical perspectives such as endogenous growth theory (Romer, 1990), which emphasizes knowledge and innovation as drivers of sustainable economic growth, and the innovation-based development model advanced by Schumpeter (1934), which positions technological innovation as a catalyst for economic transformation. The findings also reflect the university-industry-government interaction model proposed by Etzkowitz and Leydesdorff (2000), which highlights the importance of collaborative innovation systems in promoting regional economic development. However, the study identified a critical gap: research activities were not perceived to significantly enhance technological awareness within the wider community. This finding suggests that while research outputs may exist and contribute internally to institutional development and capacity building, their dissemination, commercialization, and community-level impact remain limited. The study concludes that, outputs and technological innovations in Benue State contribute to economic growth at a moderate level, but their broader socio-economic impact is constrained by limited community engagement, insufficient knowledge transfer mechanisms, and possibly weak industry linkages.

### **Recommendations**

Based on the findings and conclusions, the following recommendations are proposed:

1. Industrial Technology departments should establish structured partnerships with local industries, Small and Medium Scale Enterprises (SMEs), and agro-processing firms in Benue State. This will enhance the practical application and commercialization of research outputs, ensuring that innovations directly address local economic needs.
2. Institutions should develop innovation hubs and technology incubation centers to facilitate prototype development, product testing, and startup creation. Such platforms will enable research findings to transition from theoretical outputs to marketable technologies.
3. Departments should intensify community-based extension services, technical exhibitions, workshops, and public awareness programs to enhance technological literacy. Bridging the gap between academic research and community awareness will increase the economic impact of innovation.
4. Government agencies and intervention bodies such as the Tertiary Education Trust Fund (TETFund) should expand targeted funding for applied and commercialization-oriented research. Dedicated grants for community-impact projects would further strengthen research contributions to economic growth.

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# Tire Technology Development and Their Impact on Vehicle Performance in Nigeria

**Victor Kwaghgba Aho, PhD<sup>1</sup>, Ihongu Moses Terngu<sup>2</sup>, Vershima Mark Nande, PhD<sup>3</sup>**  
<sup>1,2,3</sup>Department of Industrial Technology, Rev. Fr. Moses Orshio Adasu University, Makurdi.

## ABSTRACT

*Tires as essential components of vehicle system play a fundamental role in vehicle performance, influencing not only safety and fuel efficiency but also the overall driving experience. Tire technology has significantly evolved over the years, impacting various factors such as traction, comfort, durability, and energy consumption. The technological advancements in tire design and materials was examines how these innovations influence vehicle performance in the Nigerian context. It particularly focuses on how tire technology impacts fuel efficiency, vehicle safety, road handling, and durability, while also considering the unique challenges posed by Nigeria's infrastructure and climate. The paper further discusses the opportunities for local adaptation and innovation in tire technology to address the specific needs of the Nigerian automotive market. Through a comprehensive review of the evolution of tire technology and its implications for vehicle performance, the paper aims to provide a thorough understanding of how tire innovations can contribute to the optimization of vehicle operations in Nigeria, fostering both economic and environmental benefits.*

KEYWORDS: Tire, Technology Development, Vehicle, Performance

## INTRODUCTION

The development of tire technology stands as a fundamental pillar in modern automotive engineering. According to Alabi (2018). Tire technology refers to the design, manufacturing processes, and innovations used in the development of tires for various types of vehicles. This technology encompasses a wide range of advancements, including materials science, tire composition; tread patterns, and manufacturing techniques. Tire technology also includes innovations such as smart tires with embedded sensors, airless tires, and eco-friendly tires designed to improve vehicle performance, safety, fuel efficiency, and environmental sustainability. As automotive technology continues to evolve, tire technology adapts to meet the increasing demands for enhanced vehicle performance, sustainability, and safety. The term development in the context of tire technology refers to the continuous evolution and improvement of tire designs, materials, and manufacturing processes. Friedrich, Heinemeyer, and Veit, (2019). Vehicle performance refers to how well a vehicle functions under various driving conditions. It encompasses a wide range of factors such as speed, acceleration, handling, braking, stability, fuel efficiency, comfort, and safety. Tire technology directly impacts all these aspects of vehicle performance.

Mohajerani et al. (2020) and Zainol et al. (2022) stated that, tire technology on vehicle performance refers to how advancements in tire design, materials, and technology influence or enhance various aspects of a vehicle's operation and the safety of its occupants. These impacts can be both direct and indirect: Tire technology can directly influence vehicle performance through improved handling, safety, fuel efficiency, and comfort. For example, advanced tire materials that reduce rolling resistance can improve fuel efficiency, while better tread designs enhance traction and cornering stability. Indirect effects include the potential to

lower long-term costs associated with tire maintenance, such as fewer tire replacements or reduced fuel consumption over the vehicle's lifespan. Tires are the primary interface between a vehicle and the road, directly influencing its performance, safety, and efficiency. A vehicle's ability to perform well is not just determined by its engine power or aerodynamics but significantly depends on the tires it uses. Historically, the evolution of tire technology has paralleled advancements in automotive engineering, contributing to improved vehicle performance in areas such as handling, comfort, safety, and fuel economy. In the 21st century, according to Buraimoh et al., (2020), the tire industry has continued to innovate, with improvements in materials, manufacturing techniques, and smart tire technologies enhancing both the performance and sustainability of modern tires.

In Nigeria, a country with diverse road conditions and climatic variations, the importance of tire technology cannot be overstated. Tire technology in the country faces unique challenges, including poor road infrastructure, fluctuating temperatures, and varying levels of vehicle maintenance. The Nigerian automotive industry is characterized by a high demand for vehicles, driven by both urbanization and the country's large population. However, despite the growth in demand, tire technology according to Ogunbiyi, (2017), Nigeria has not always kept pace with global advancements due to economic constraints, limited access to high-quality tire brands, and the lack of awareness about tire maintenance and performance. Tire technology development has the potential to address some of these challenges, particularly with advancements in tire materials, tread design, and innovations such as run-flat and eco-friendly tires. The impact of such advancements on vehicle performance is profound. Tires affect a variety of vehicle characteristics, such as fuel efficiency, road handling, and safety, all of which are critical to users, where road conditions often range from well-paved highways to poorly maintained, uneven surfaces

(Alabi, 2018), noted that the harsh climate in some regions of accelerates tire wear, thus necessitating tires that can withstand extreme temperatures and provide better durability. The evolution of tire technology has made it possible for vehicles to perform optimally in these demanding conditions, offering enhanced safety, reduced fuel consumption, and improved driving comfort. For instance, tires designed with low rolling resistance have been shown to reduce fuel consumption, which is particularly important in a country where fuel costs can be volatile and constitute a significant portion of transportation expenses (NAMA, 2019). Moreover, advanced tire technologies such as intelligent, sensor-equipped tires provide real-time data on tire pressure, temperature, and wear, offering the potential to increase safety and vehicle longevity.

Alabi. (2018), Stated that, the impact of tire technology on vehicle performance is not without its challenges. One major obstacle is the cost of high-quality tires, which may be prohibitively expensive for the average users. Additionally, many tire users still rely on low-quality, imported tires that may not be suited for local driving conditions. Furthermore, there is a need for greater awareness regarding the importance of tire maintenance and the benefits of modern tire technologies.

### **Tire Technology Development and Evolution of Tire Materials**

Alabi. (2018), tire technology has evolved significantly over the past century, with key innovations improving vehicle performance, safety, durability, and fuel efficiency. This evolution has been driven by advances in materials science, manufacturing techniques, and a deeper understanding of tire dynamics in relation to vehicle behavior and road conditions. Modern tire technologies have revolutionized not only the driving experience but also the sustainability of automotive transportation. Some of the major developments in tire technology, including materials, design, construction, and innovations in tire monitoring.

The materials used in tire construction have undergone significant changes to improve tire performance. Early tires were made from solid rubber or bands of iron, but as technology advanced, air-filled rubber tires became the standard. Key materials used in modern tire technology include:

1. **Rubber Compounds:** The development of synthetic rubber during World War II led to the ability to produce tires that were more durable and less susceptible to wear than their natural rubber counterparts. Modern tires incorporate a combination of natural and synthetic rubbers, with additives such as carbon black, silica, and plasticizers. These additives improve tire longevity, traction, and fuel efficiency (Friedrich et al., 2019).
2. **Silica and Carbon Black:** Silica is widely used in the tread compound of modern tires because it improves wet traction and reduces rolling resistance, thus enhancing fuel economy. Carbon black, reinforcing filler, has been used for many years in tire construction, providing durability and wear resistance (Buraimoh et al., 2020). The use of silica has become more widespread due to its ability to reduce energy loss, making tires more eco-friendly by lowering fuel consumption.
3. **Steel Belts and Nylon Cords:** Steel belts are commonly used in modern tire construction to provide strength and maintain the tire's shape under high pressure. These steel belts enhance the tire's durability and allow for better performance at high speeds. Nylon and polyester cords are also used in the tire's construction to provide additional strength and flexibility (Alabi, 2018).

### **The Development Radial and Bias Ply Tires on Vehicles**

The development of radial tire construction, which was introduced in the 1940s, marked a major turning point in tire technology. Prior to this, tires were constructed using bias ply technology. In a radial tire, the layers of the tire's fabric are arranged at 90 degrees to the direction of travel, with steel belts around the tread. This design allows for better fuel efficiency, longer tire life, and a smoother ride. Radial tires are more resistant to heat and wear, providing better traction and stability (Friedrich et al., 2019). This construction also allows for better handling on highways and smoother rides on rougher roads. Bias ply tires, which were the standard for many years, feature layers of fabric arranged diagonally across the tire. While they offer better sidewall strength, they tend to have higher rolling resistance, which leads to decreased fuel efficiency. These tires are still used for off-road vehicles or for certain heavy-duty applications (NAMA, 2019). The shift to radial tires significantly improved vehicle performance, making them the industry standard for passenger vehicles and light trucks worldwide.

### **Run-Flat Tires**

Run-flat tires are designed to maintain their performance even after a puncture or loss of air pressure, allowing vehicles to continue driving for a limited distance (usually 50-100 miles) without the need for immediate tire replacement. This technology offers convenience and safety, as it eliminates the need for changing a flat tire in hazardous or remote locations. Buraimoh et al., (2020), stated that run-flat tires are typically constructed with reinforced sidewalls that support the weight of the vehicle even when there is a loss of air pressure. There are two main types of run-flat tires:

Self-supporting run-flat tires: These tires have stiffer sidewalls that can support the vehicle's weight even after air loss. They can still function at low or no air pressure, albeit with some reduction in handling performance and comfort.

Support ring run-flat tires: These use a rubber or plastic support ring within the tire that helps support the weight of the vehicle when air pressure is lost (Friedrich et al., 2019). Although run-flat tires are a valuable innovation, they can be more expensive than conventional tires and are not always suitable for all vehicles or driving conditions. Despite these limitations, their convenience has led to their increased use in high-performance and luxury vehicles.

### **Smart Tires and Tire Monitoring Systems**

With the advent of smart technology, modern tires are now equipped with sensors that provide real-time data on tire conditions, such as pressure, temperature, and wear levels. These sensors, often referred to as Tire Pressure Monitoring Systems (TPMS), are now standard in many vehicles. According to NAMA, (2019), the primary benefit of TPMS is that it provides drivers with real-time alerts about underinflated or overinflated tires, which can reduce the risk of accidents, improve fuel efficiency, and prolong the life of the tires. Furthermore, the development of smart tires has expanded to include sensors embedded directly within the tire to monitor not only pressure but also temperature, wear patterns, and tread depth. This data can be transmitted to the vehicle's onboard computer or to a mobile app, allowing drivers to track tire health over time. Friedrich et al., (2019), opined that by ensuring optimal tire conditions, smart tires help reduce the likelihood of blowouts or uneven wear, and improve overall vehicle performance and safety. These tire monitoring systems also play an important role in fleet management, as they allow fleet operators to track the health of tires across a large number of vehicles, ensuring that tires are always in the best condition for maximum performance and safety.

### **Eco-Friendly Tires**

Environmental sustainability has become a critical factor in tire development due to growing concerns over carbon emissions and fuel consumption. Tires with low rolling resistance (LRR) are designed to reduce energy loss as the tire rolls, which, in turn, enhance fuel efficiency. The reduced rolling resistance leads to lower fuel consumption and decreased greenhouse gas emissions, making them a more eco-friendly option for both individual drivers and the global automotive industry. Manufacturers are also exploring the use of renewable materials in tire construction, such as biodegradable rubber, recycled materials, and sustainable production methods (Adeleke et al., 2020). For example, some manufacturers have started producing tires using bio-based oils instead of petroleum-based oils, and there is ongoing research into developing tires from alternative sources like dandelions and algae, which could reduce dependence on fossil fuels and minimize environmental impact. These advancements are particularly important as governments and consumers alike demand more sustainable products, and the tire industry faces increasing pressure to reduce its environmental footprint.

### **Ultra High-Performance Tires (UHP)**

With the growing popularity of sports cars, luxury vehicles, and high-performance vehicles, tire manufacturers have focused on creating ultra-high-performance (UHP) tires designed to provide superior handling, responsiveness, and safety. These tires are characterized by their low profile, wide tread, and advanced tread compounds that provide enhanced grip, cornering performance, and stability at high speeds. UHP tires often use high-silica compounds, which offer superior wet traction and reduced rolling resistance. According to Alabi, (2018), the development of UHP tires has been crucial in ensuring that high-performance vehicles, such as sports cars and luxury sedans, can perform optimally on both dry and wet surfaces. As

vehicle performance standards continue to increase, UHP tires will remain a vital part of the automotive landscape.

### **Impact of Tire Technology on Vehicle Performance in Nigeria**

The impact of tire technology on vehicle performance is a crucial factor in improving vehicle safety, fuel efficiency, and overall handling. In Nigeria, where road conditions, climate, and economic factors significantly influence vehicle performance, tire technology plays an even more critical role. As a country with a rapidly growing automotive market, Nigeria faces various challenges, such as poor road infrastructure, fluctuating climate conditions, and economic constraints. These factors necessitate the adoption of advanced tire technologies to optimize vehicle performance in ways that improve safety, reduce fuel consumption, enhance comfort, and increase tire durability. This section explores how tire technology influences vehicle performance in Nigeria, focusing on key areas such as fuel efficiency, safety, vehicle handling, and tire durability, and how these factors contribute to addressing the unique challenges faced by Nigerian motorists.

#### **Fuel Efficiency and Environmental Impact**

One of the most significant advancements in tire technology is the development of low rolling resistance (LRR) tires. These tires reduce the amount of energy needed for a vehicle to move forward, thereby decreasing fuel consumption. In Nigeria, where fuel prices are volatile and fuel efficiency is critical for both individual vehicle owners and fleet operators, the impact of LRR tires is substantial. Tires with low rolling resistance are designed to minimize friction between the tire and the road surface, which in turn reduces energy loss and improves fuel economy (Buraimoh et al., 2020). Studies have shown that tires designed for low rolling resistance can reduce fuel consumption by up to 3-5%, depending on driving conditions and the vehicle's make and model (Adeleke et al., 2020). Given the high cost of fuel in Nigeria, which often leads to financial strain for both individuals and businesses, LRR tires represent an important advancement for reducing transportation costs and mitigating the economic impact of rising fuel prices.

Moreover, these tires have environmental benefits by reducing the overall carbon footprint of vehicle operations. Alabi, (2018), decried that in Nigeria, where air quality is a growing concern in urban centers such as Lagos, adopting fuel-efficient tire technology can contribute to a reduction in greenhouse gas emissions, further aligning with global sustainability goals.

#### **Vehicle Safety and Stability**

Tire safety is essential for preventing accidents and ensuring the well-being of drivers and passengers. Tire failure, whether due to under-inflation, wear, or damage, is a leading cause of vehicle accidents worldwide. In Nigeria, where road conditions are often subpar, tire safety is even more critical. Poorly maintained roads, potholes, and heavy rainfall during the wet season make it difficult for drivers to maintain optimal vehicle control. Advanced tire technologies, such as smart tire systems and improved tread designs, play a vital role in enhancing safety and stability on Nigerian roads.

#### **Tire Pressure Monitoring Systems (TPMS)**

TPMS sensors are designed to alert drivers when tire pressure drops below a safe level. Under-inflated tires are more prone to wear, overheating, and blowouts, especially on poorly paved roads. With TPMS, drivers are made aware of low pressure before it becomes dangerous, helping to avoid tire-related accidents. In Nigeria, where regular tire maintenance is often overlooked, the widespread use of TPMS could significantly improve road safety (Ogunbiyi,

2017). TPMS is also a standard feature in most new vehicles and is becoming more accessible to Nigerian drivers through the used car market.

### **Tread Design and Traction:**

Advanced tire tread designs, such as asymmetrical treads and high-void patterns, are designed to improve traction, especially on wet or slippery surfaces. These tread designs help maintain better grip on the road, reducing the risk of hydroplaning, a common problem in Nigeria during the rainy season. Additionally, tire designs that optimize traction in both wet and dry conditions contribute to improved vehicle stability, which is particularly important in Nigeria's diverse driving environments, from smooth highways to rough rural roads (Alabi, 2018).

### **Vehicle Handling, Comfort and Cornering Stability:**

Vehicle handling and comfort are directly affected by the tires' ability to absorb shocks and maintain traction with the road surface. In Nigeria, where the quality of roads can range from smooth highways to rutted, uneven paths, tire technology plays a critical role in ensuring that vehicles maintain good control and comfort, particularly on challenging road surfaces. Tires equipped with advanced rubber compounds and reinforced sidewalls are better able to absorb shocks from rough or uneven roads. These tires reduce vibrations, offering a smoother and more comfortable ride. Buraimoh et al., (2020), stated that Nigerian drivers, who often face long-distance travel on poorly maintained roads, tires with better shock absorption are essential to improving comfort and reducing fatigue, especially on rural routes.

The responsiveness of a vehicle in terms of handling, steering, and cornering is largely influenced by the tire's ability to maintain optimal contact with the road. Tires designed for performance or all-terrain use offer better handling and stability, which is particularly important in Nigerian cities where traffic congestion, erratic driving behavior, and variable road conditions make precise control crucial. Alabi, (2018), posited that tires that provide better grip and stability allow for more accurate steering responses and safer cornering. In Nigeria, where the weather is generally hot and rainy, but also varies in different regions, tires designed to handle both wet and dry conditions are essential. All-season tires are popular in urban areas for their ability to offer comfort, handling, and performance across a variety of weather conditions. Similarly, all-terrain tires are beneficial for those living in rural or less-developed areas where road surfaces can be rough and unpaved. Friedrich et al., (2019) concluded that these tires provide better traction and durability, improving vehicle stability on both paved and unpaved roads.

### **Durability and Tire Longevity**

Tire durability is a critical factor in vehicle performance, particularly in a country like Nigeria, where the quality of roads can cause excessive tire wear and tear. Tires that offer superior durability and resistance to damage, such as cuts, abrasions, and punctures, can significantly reduce the frequency and cost of tire replacements. The introduction of reinforced sidewalls and high-strength rubber compounds in tire design has greatly enhanced the durability of modern tires. Tires that are built with stronger sidewalls and better resistance to abrasions perform well in harsh road conditions, which are common in Nigeria, particularly on rural roads or roads in disrepair. According to Adeleke et al., (2020), tires with longer-lasting tread help reduce the frequency of tire changes, leading to lower maintenance costs for vehicle owners.

### **Cost and Affordability Challenges**

Despite the benefits that advanced tire technologies bring to vehicle performance, cost remains a significant barrier for many Nigerian drivers. The affordability of high-performance

or technologically advanced tires can be prohibitive, especially in a country where a large portion of the population relies on used vehicles or inexpensive tire brands. Local manufacturing of tires could help reduce costs, but the industry is still growing, and most high-quality tires are imported. According to Adeleke et al., (2020), educating the Nigerian public about the long-term savings that come with using high-quality, durable tires may help bridge this gap. Although initially more expensive, quality tires can save money by reducing fuel consumption, increasing safety, and lowering maintenance costs.

### **Pathways for the Future of Tire Technology**

The future of tire technology is poised to be shaped by several key trends and advancements, driven by innovations in materials, sustainability, connectivity, and smart technologies. These developments are expected to address not only the evolving needs of the automotive industry but also the global challenges of fuel efficiency, safety, and environmental sustainability. The following outlines the key pathways for the future of tire technology:

1. **Sustainability and Eco-friendly Tires:** As concerns over climate change and environmental sustainability continue to grow, the tire industry is actively exploring ways to reduce the environmental impact of tire production, usage, and disposal. Future tire technologies will focus heavily on the following aspects: Bio-based Materials; Recyclable Tires; and Low Rolling Resistance.
2. **Smart Tires and Connectivity:** The advent of smart technology and the growing trend of connected vehicles are expected to play a significant role in the future of tire technology. Tires will become increasingly intelligent, equipped with sensors and communication systems that allow them to interact with vehicles and their drivers in real-time, such as Tire Pressure Monitoring Systems (TPMS); Vehicle-to-Tire Communication; and Wearable Tire Sensors.
3. **Autonomous Vehicles and Specialized Tires:** As autonomous vehicles (AVs) become more prevalent, tire technology will need to evolve to meet the specific demands of self-driving cars. Autonomous vehicles rely heavily on sensors, data, and real-time decision-making, and tires will play a crucial role in ensuring these vehicles are safe, efficient, and comfortable, such as Enhanced Traction and Stability; Durability for High-Mileage Use; and Adaptive Tire Technologies.
4. **Advanced Manufacturing and 3D Printing:** The future of tire production will see a significant shift toward advanced manufacturing techniques, including 3D printing and robotic automation. These technologies promise to revolutionize the way tires are designed, produced, and customized. These include 3D Printed Tires and Smart Manufacturing Processes using robotics and artificial intelligence (AI) to enhance production efficiency and reduce defects.
5. **Airless Tires and Alternative Tire Concepts:** Another exciting pathway for the future of tire technology is the development of airless tires, which eliminate the risk of tire deflation altogether. Airless tires are designed using a unique structure of flexible spokes or a mesh that can support the vehicle without the need for air pressure; and Self-Healing Tires that can repair minor punctures or damage automatically.

### **Conclusion**

Tire technology has an undeniable impact on vehicle performance, particularly in a country like Nigeria, where road conditions, climate, and economic factors shape the automotive

environment. Advancements in tire materials, designs, and smart technologies offer significant improvements in safety, fuel efficiency, and overall vehicle performance. However, for Nigeria to fully benefit from these technological developments, addressing infrastructural challenges, improving public awareness, and making high-quality tires more affordable are key steps. The growth of the local tire manufacturing industry could also provide a solution to some of these challenges, promoting both economic and technological development in Nigeria's automotive sector. This paper highlights the pivotal role tire technology plays in optimizing vehicle performance and safety in Nigeria, while also emphasizing the challenges and opportunities unique to the region. This paper explores these issues existing and examining the evolution of tire technology, its impact on vehicle performance, and the specific challenges faced by the automotive sector. It also discusses the opportunities for innovation and local manufacturing to improve tire quality and affordability.

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# A Critical Appraisal of Empirical Authenticity in Nigerian Technological Research: The Perspective of a Technology Educator

Nule Joseph Shimagande<sup>1</sup>, & Upwa Fanen Emmanuel<sup>2</sup>

<sup>1,2</sup>Department of Industrial Technology, Rev. Fr. Moses Orshio Adasu University, Makurdi.

Corresponding Author: Nule Joseph Shimagande, [josephnule@gmail.com](mailto:josephnule@gmail.com)

## ABSTRACT

*This appraisal critically examines the empirical authenticity of technological research within Nigeria's Technical and Vocational Education and Training (TVET) sector. Despite TVET's role as a catalyst for industrialisation and the Fourth Industrial Revolution (4IR), a significant divergence exists between theoretical research ideals and practical academic output. This paper identifies a prevailing "methodological mono-culture," characterised by an over-reliance on descriptive surveys (exceeding 90% in some faculties) at the expense of experimental designs. This trend is exacerbated by chronic infrastructural decay, erratic power supply, and a profound disconnect between academia and industry. Furthermore, a burgeoning ethical crisis, marked by a 22% admission rate of fabrication, falsification, or plagiarism, undermines the integrity of the nation's empirical research enterprise. Utilising meta-analytic findings and evaluative frameworks like the Kirkpatrick model, the analysis reveals that even when pedagogical interventions succeed, they often fail to translate into economic impact. The study concludes that reclaiming empirical integrity requires a structural realignment toward longitudinal experimentation, ethical fortification, and industry-synched research agendas within the Nigerian context.*

KEYWORDS: TVET, Empirical Authenticity, Methodological Mono-culture, Research Misconduct (FFP), Kirkpatrick Model

## INTRODUCTION

Technical and Vocational Education and Training (TVET) is globally recognised as a critical driver for sustainable development, industrialisation, and the cultivation of a skilled workforce capable of navigating the complexities of the Fourth Industrial Revolution (UNESCO, 2024). In Nigeria, the strategic importance of TVET is enshrined in national policy as a pathway to economic diversification and technological advancement (Odo et al., 2024). However, the sector's capacity to fulfil this transformative mandate is intrinsically linked to the robustness and applicability of the research that underpins its pedagogical and practical frameworks. The extent to which this research reflects empirical authenticity, therefore, becomes a pivotal determinant of TVET's overall efficacy and societal relevance. Despite its purported significance, a discernible chasm has emerged between the theoretical ideals espoused in Nigerian TVET scholarship and the practical realities of its academic output. A growing body of evidence suggests that the sector's research enterprise is constrained by a "methodological mono-culture." This phenomenon is characterised by a disproportionate reliance on descriptive survey designs, which, in some faculties, constitute over 90% of all empirical studies (Faculty of Education UNN, 2018). This over-reliance occurs at the expense of more robust experimental, quasi-experimental, and longitudinal designs that are essential for establishing causal inferences and testing the efficacy of technological interventions. Such methodological

stagnation limits the generalisability and practical utility of research findings, impeding the development of evidence-based solutions to persistent technical challenges.

The impediments to rigorous empirical inquiry in Nigerian TVET are multifaceted and deeply entrenched. Chronic infrastructural decay, including erratic power supply and inadequate laboratory facilities, creates a prohibitive environment for complex technological research (National Communications Commission, 2024). This systemic deficiency is compounded by a profound disconnect between academic institutions and the industries they are meant to serve. The absence of sustained industry-academia collaboration results in research agendas that are often misaligned with the evolving needs of the labour market, rendering scholarly output largely theoretical and devoid of immediate practical application (Bakare et al., 2025; Stakeholder Partnership Thesis, 2018). Beyond these structural and collaborative deficits, the integrity of the empirical research enterprise itself is under threat from a burgeoning ethical crisis. Recent meta-analyses indicate a concerning prevalence of research misconduct, with admission rates of fabrication, falsification, and plagiarism reaching approximately 22% among some academic cohorts (Global Publication House, 2025). According to Oliha and Osiobafoa (2024), this erosion of academic integrity, often exacerbated by a "publish or perish" culture and inadequate research ethics training fundamentally undermines the trustworthiness of the nation's scientific output and calls into question the validity of the evidence base informing TVET policy and practice.

This appraisal, therefore, seeks to critically examine the empirical authenticity of technological research within Nigeria's TVET sector. Utilising meta-analytic findings and established evaluative frameworks, such as the Kirkpatrick model (Edidiong et al., 2024), this paper analyses the interplay between methodological choices, infrastructural constraints, and ethical practices. It argues that even when pedagogical interventions demonstrate success at immediate levels of learning, their failure to translate into tangible economic impact or industry-relevant skills signals a profound disconnection between academic research and its purported real-world objectives. The paper concludes by advocating for a structural realignment of the research culture, emphasising the necessity for longitudinal experimentation, rigorous ethical fortification, and the co-creation of research agendas with industry partners to restore empirical integrity and enhance the societal relevance of TVET in Nigeria

### **The Epistemological Crisis: Defining Empiricism in a Technical Vacuum**

The epistemological foundation of technological research is predicated on a distinct form of empiricism, one that diverges significantly from purely theoretical or philosophical inquiry. Within the domain of Technical and Vocational Education and Training (TVET), the gold standard for empirical rigour is increasingly defined by international frameworks, such as those promulgated by UNESCO-UNEVOC, which advocate for competence-based occupational standards (UNESCO-UNEVOC, 2021). These standards mandate that both training and assessment be objective, demonstrably aligned with defined competency levels, and verified through the observation of authentic performance in-situ (UNESCO-UNEVOC, 2021). Nworgu (2015) and Uwaifo (2006) observed that for research to legitimately claim the mantle of empiricism in this context, it must therefore transcend mere theoretical postulation. This necessitates the rigorous testing of hypotheses through controlled experimentation or the systematic, replicable observation of technical phenomena within real-world or simulated environments

In Nigeria, however, technological research within the TVET sector frequently struggles to sustain this fundamental connection to the material world. This disjuncture represents a profound epistemological crisis, wherein the methods of inquiry have become decoupled from

the very nature of the technical reality they seek to investigate. The resultant 'crisis of relevance,' a persistent feature of the Nigerian education system since the 1980s, can be attributed, in significant part, to a research culture that fails to bridge the gap between theoretical conjecture and practical outcomes, and between scholarly output and policy formulation (Jega, 2017). The research produced often exists in a vacuum, its findings insufficiently robust or applicable to inform the development of curricula, pedagogical tools, or industrial processes.

This detachment is exacerbated by a prevailing institutional culture that undervalues evidence. Political and bureaucratic leadership in the educational sector has frequently exhibited a marked indifference, or even active resistance, to research-driven evidence, preferring instead an incremental, 'muddling through' approach to resolving complex educational challenges (Jega, 2017). This systemic disregard for empirical findings creates a deleterious feedback loop. When researchers perceive that their meticulously gathered data will be systematically ignored by policymakers, the intrinsic motivation for methodological rigour is severely undermined. This dynamic can lead to a proliferation of research that lacks the depth, validity, and practical orientation required to catalyse genuine industrial transformation (Jega, 2017; Ayonmike et al., 2015). The consequence is a body of scholarly work that is not only empirically fragile but also epistemologically misaligned with the practical, problem-solving ethos that should define technological research in a developing economy.

### **Methodological Mono-culture: The Dominance and Limitation of the Survey Trap**

A critical examination of the research designs prevalent within Nigeria's Technical and Vocational Education and Training (TVET) and technology education sectors reveals a pronounced and epistemologically limiting trend. Quantitative inquiry, by its nature, encompasses a diverse array of methodological approaches, each suited to addressing distinct types of research questions. These range from experimental and quasi-experimental designs, which are essential for establishing causal relationships, to causal-comparative and correlational studies, which explore differences and associations between variables (Nworgu, 2015). However, despite this methodological plurality, the landscape of Nigerian educational research is characterised by an overwhelming and disproportionate reliance on a single approach, which is the descriptive survey research design.

This phenomenon, which may be termed a 'methodological mono-culture,' is starkly illustrated by meta-analytic evidence from Nigerian higher education. Syntheses of completed postgraduate theses and peer-reviewed journal articles indicate that, within some faculties of education and social sciences, the descriptive survey design accounts for in excess of 90% of all empirical studies (Faculty of Education UNN, 2018). While the survey method holds undeniable utility for capturing attitudes, perceptions, and demographic trends at a specific point in time, its dominance to the near-exclusion of other designs signals a profound epistemological imbalance. The implications of this imbalance are particularly acute for a field like TVET, which is fundamentally concerned with the acquisition of measurable skills, the efficacy of pedagogical interventions, and the application of knowledge in practical settings, all of which demand methodologies capable of demonstrating change and verifying competence.

The ascendancy of the descriptive survey can be attributed to a confluence of factors, including its perceived ease of administration, its relatively low cost, and its compatibility with the statistical analysis techniques most familiar to researchers. However, its dominance comes at a significant cost. In relying almost exclusively on self-reported data and cross-sectional snapshots, researchers forfeit the opportunity to observe technical phenomena directly, to manipulate variables in controlled environments, or to track the development of competencies

over time (UNESCO-UNEVOC, 2021). Consequently, the field is left with a substantial body of literature describing what stakeholders think or feel about technological education, but a comparative dearth of robust evidence on what actually works in terms of pedagogical practice, skills acquisition, and long-term industrial impact. This methodological inertia not only constrains the theoretical development of the discipline but also severely limits the practical utility of research for informing evidence-based policy and curriculum reform in the Nigerian TVET sector.

**Table 1:** *Comparison of Core Research Methodologies in Technology Education*

<b>Research Design</b>	<b>Core Objective</b>	<b>Empirical Mechanism</b>	<b>Practical Limitation in Nigeria</b>
Experimental	Establish cause-effect relationships (Ayonmike et al., 2015)	Manipulation of independent variables under controlled conditions (Nworgu, 2015)	High cost; requires functional workshops and stable power (Ayonmike et al., 2015)
Quasi-Experimental	Test interventions without randomisation (Bakare et al., 2023 )	Pre-test/post-test of groups undergoing different treatments (Agbaje et al., 2022 )	Difficulty in controlling external school-based variables (Uduafemhe, 2021 )
Descriptive Survey	Describe population characteristics or opinions (Nworgu, 2015 )	Standardised questionnaires and structured interviews (Faculty of Education UNN, 2018 )	Strictly observational; cannot prove causation or technical efficacy (Faculty of Education UNN, 2018 )
Case Study	In-depth analysis of a single subject (Faculty of Education UNN, 2018 )	Collection of detailed qualitative and quantitative data (Bakare et al., 2023 )	Limited generalisability to the broader national context (Faculty of Education UNN, 2018 )

The prevalence of the descriptive survey in technological research is fundamentally problematic. Technology, by its very nature, is a field of interventions, processes, and material outcomes (Odo et al., 2024). When research in this field is reduced to documenting the opinions of lecturers or students regarding the inadequacy of facilities, rather than experimenting with new pedagogical methods or technical processes despite those inadequacies, the research ceases to be truly 'technological' and becomes 'sociological' (Uduafemhe, 2021). Furthermore, the integrity of these surveys is often compromised by unstatistical methods for determining sample size (Faculty of Education UNN, 2018). Many researchers rely on arbitrary percentage 'suggestions' rather than mathematically proven formulas, leading to data that lacks a significant confidence level and possesses a high margin of error (Faculty of Education UNN, 2018). For research to be considered empirical, the data must be statistically dependable and generalisable; the current 'survey trap' in Nigerian academia fails this test (Faculty of Education UNN, 2018). According to Ayonmike et al. (2015), this reliance on surveys is frequently a defensive response to the lack of functional laboratories, as researchers find it easier to distribute a questionnaire than to conduct a lab-based experiment in a workshop lacking power or equipment

### **Infrastructural Decay: The Physical Barrier to Empirical Observation**

The foundational claim of any empirical research enterprise is that phenomena exist to be observed and that adequate mechanisms are available for their systematic observation

(Nworgu, 2015). Within Nigeria's Technical and Vocational Education and Training (TVET) institutions, however, the physical substrate necessary for such observation, the workshops, laboratories, and equipment that constitute the material basis of technical inquiry, exists in a state of advanced dilapidation (Ayonmike et al., 2015). This infrastructural decay fundamentally undermines the possibility of conducting empirical research that is grounded in the observation of authentic technical practice, rendering the pursuit of rigorous, experimentally verified knowledge profoundly constrained.

The empirical evidence for this decay is both extensive and unequivocal. Technical and vocational institutions across Nigeria are consistently characterised by inadequate infrastructure, obsolete equipment, and workshops that have fallen into disuse or complete non-functionality (Ayonmike et al., 2015). A comprehensive nationwide assessment conducted in 2025 across 320 TVET institutions in all 36 states and the Federal Capital Territory revealed the stark magnitude of this crisis. The UNESCO-led evaluation found that 60 per cent of classrooms and workshops require significant rehabilitation, including window replacement, flooring repairs, and improved lighting (New Telegraph, 2026). Also, less than 25 per cent of institutions have reliable power supply for digital training, while over half report unreliable or no electricity access whatsoever (New Telegraph, 2026). For an empirical tradition that depends on the operation of machinery, the observation of technical processes, and the replication of industrial conditions, such power deficits are existentially crippling.

The implications for empirical observation extend beyond mere infrastructure to the very tools of technical practice. The Executive Secretary of the Tertiary Education Trust Fund (TETFund) has acknowledged that many polytechnics, which should serve as pillars of TVET, contain laboratories and workshops equipped with obsolete machinery that bears no relation to contemporary industrial standards (The Guardian, 2025). This observation echoes earlier documentation of technical colleges where equipment supplied decades ago, in some cases as far back as 1964, remains in use, long past any reasonable lifespan for functional machinery (Daily Trust, 2014). In such environments, the equipment available for student training and, by extension, for research observation, bears at best a passing resemblance to the technologies actually deployed in Nigerian industries. Teachers are consequently compelled to resort to diagrammatic representations on blackboards, substituting symbolic abstraction for direct empirical engagement with operational machinery (Daily Trust, 2014)

**Table 2: Strategic Infrastructure Deficits and Research Implications**

<b>Infrastructure Component</b>	<b>National Deficit/Status</b>	<b>Impact on Technological Empiricism</b>
Energy/Power Supply	Persistent failures and erratic supply (Stonehill Research, 2024 )	Prevents longitudinal experiments; damages sensitive electronic research tools (Opesanwo & Anwana, 2023 )
ICT/Internet	Only 54,000 km of fibre backbone; 4G deployment at 45% (NCC, 2024 )	Limits access to cloud-based research tools and global databases (Stonehill Research, 2024 )
Technical Workshops	Many schools lack functional workshops or modern tools (Ayonmike et al., 2015 )	Forces practical subjects to be taught and researched theoretically (Uwaifo, 2006 )
General Funding	NIIMP estimates \$3 trillion required over 30 years (NCC, 2024)	Chronic stagnation in facility maintenance and curriculum development (Ayonmike et al., 2015)

The 2013 National Integrated Infrastructure Master Plan (NIIMP) showed a massive deficit across core sectors, including energy and ICT (National Communications Commission [NCC], 2024). For the technological researcher, this translates to a reality where 'Metal-work Technology' or 'Wood-work Technology' are researched primarily through theoretical scores because the workshops lack the consumables or the machinery for experimental validation (Uwaifo, 2006). Studies have shown that while there is a significant relationship between theoretical and practical performance, the lack of emphasis on the practical aspects in Nigerian universities produces graduates who are knowledgeable in theory but deficient in the practical skills required by the labour market (Uwaifo, 2006). The 'empirical' nature of a study is hollow if the researcher is 'faking' the environment or if the 'technical' findings are based on machines that have been out of industrial use for decades (UNESCO-UNEVOC, 2021; Ayonmike et al., 2015). Consequently, Nigerian technological research often suffers from a 'ghost empiricism', where the data collected relates to a simulated or historical reality rather than the current industrial frontier (Sylvester, 2021; Ayonmike et al., 2015).

### **The Political Economy of Research: Funding, Motivation, and Brain Drain**

Empirical research is an expensive undertaking, requiring consumables, equipment maintenance, and field-work logistics (Ayonmike et al., 2015). In Nigeria, the financial environment for researchers is one of profound scarcity (Global Publication House, 2025 ). Global Publication House (2025) again noted that the nation currently spends less than 1% of its GDP on research and development. While bodies like the Tertiary Education Trust Fund (TETFund) provide some support, their selection processes are often hampered by inadequate publicity, lack of knowledge about funding agencies, and the exclusion of dedicated research institutes (Global Publication House, 2025 ). A staggering 42.98% of researchers in Nigeria report a total lack of research funding, leading many to self-fund their studies from their salaries (Global Publication House, 2025 ). Global Publication House (2025) and Okonta and Rossouw (2014) noted that this creates a 'poverty-research cycle' of inadequate funding leading to compromised research designs, which in turn results in low-impact publications that fail to attract international grants or industrial interest

**Table 3:** *Factors Influencing Researcher Productivity in Nigeria*

<b>Factor</b>	<b>Statistical Impact on Productivity</b>	<b>Source</b>
Lack of Research Funding	51.1% cited as primary limiting factor	(Global Publication House, 2025 )
Brain Drain	Affects 17.11% of the research population	(Global Publication House, 2025 )
Lack of Motivation	8.85% of respondents reported low motivation	(Global Publication House, 2025 )
Technical Challenges	Reported by 4.68% of researchers	(Global Publication House, 2025 )

This financial pressure, combined with high teaching loads and excessive administrative duties, significantly weakens the motivation for rigorous empirical inquiry (Ayonmike et al., 2015 ). The resulting 'brain drain' sees the most capable empirical researchers migrating to environments where their expertise is supported by adequate resources (Global Publication House, 2025 ). For those who remain, the desire for career progression, which in Nigeria is

tied almost exclusively to publication count, often takes precedence over the empirical quality of the research itself (Global Publication House, 2025).

### **Ethical Crisis: The Shadow of Fabrication, Falsification, and Plagiarism (FFP)**

Perhaps the most damaging indictment of the empirical status of technological research in Nigeria is the rising prevalence of Fabrication, Falsification, and Plagiarism (FFP) (Global Publication House, 2025). Driven by the 'publish or perish' culture and inadequate ethics training, FFP has emerged as a significant threat to the integrity of the Nigerian academic enterprise (Global Publication House, 2025; Okonta & Rossouw, 2014).

**Table 4:** *Prevalence of Research Misconduct in Nigeria*

<b>Misconduct Type</b>	<b>Admission/Prevalence Rate</b>	<b>Predictors and Drivers</b>
Fabrication	14.4% in specific samples	Pressure to publish; knowledge gaps (Agbaje et al., 2013)
Falsification	9.8% in specific samples	Desire for 'preferred' results (Agbaje et al., 2013)
Plagiarism	4.5% to 8.92% frequency	Inability to identify plagiarism (Agbaje et al., 2013; Oliha & Osiobaifoa, 2024)
Inadequate Records	29.5% (most frequent wrongdoing)	Poor mentoring; lack of oversight (Agbaje et al., 2013)
Salami Slicing	5.3% (redundant publication)	Academic promotion requirements (Agbaje et al., 2013)

In a first-time study of its kind in Africa, approximately 22% of researchers admitted to at least one of fabrication, falsification, or plagiarism (Agbaje et al., 2013). Fabrication involves inventing data, while falsification entails altering research materials or reporting wrong results to support a specific hypothesis (Agbaje et al., 2013). These practices are not merely ethical lapses; they are a direct negation of empiricism (Global Publication House, 2025). If the data is faked, the research is no longer an observation of reality but a manufactured fiction (Agbaje et al., 2013). The consequences of FFP are multifaceted, including the erosion of public confidence in research institutions, the impediment of academic advancement, and the deterioration of Nigeria's global academic ranking (Global Publication House, 2025; Oliha & Osiobaifoa, 2024). When postgraduate students are not adequately trained in ethics or are aware that plagiarism detection software like Turnitin and many others are rarely used due to subscription costs, the cycle of academic dishonesty is perpetuated (Opesanwo & Anwana, 2023 ; Wittenberg, 2024).

### **The TVET-Industry Gap: Research in a Vacuum**

The ultimate test of empirical technological research is its utility in solving real-world industrial problems (UNESCO, 2024). However, Nigerian TVET institutions suffer from a profound disconnect from the industry (Bakare et al., 2023). This disconnect is manifested in outdated curricula that do not reflect current industry needs and a lack of stakeholder partnerships (Sylvester, 2021; Ayonmike et al., 2015). A survey of 22 technical colleges across four geopolitical zones revealed extremely low internal efficiency, with only two colleges achieving an efficiency index above 50% (Stakeholder Partnership Thesis, 2018 ). Furthermore, research indicated a highly disproportionate ratio of technical colleges to general education schools,

ranging from 1:70 to 1:138 (Stakeholder Partnership Thesis, 2018 ). This scarcity of technical institutions is compounded by a lack of collaboration; where only 32% of technical colleges were found to be involved in any form of partnership with outside organisations (Stakeholder Partnership Thesis, 2018 ). The failure to use good theories to inform policies has led to a 'crisis of relevance' where the education acquired does not match the needs of employers, resulting in approximately 11 million unemployed youth (Jega, 2017 ). In such a climate, research into 'innovation' or 'skill acquisition' often occurs in a vacuum (Stakeholder Partnership Thesis, 2018 ). Without the 'Triple Helix' interaction between universities, research institutes, and firms, the empirical findings of technological research remain siloed in library repositories, poorly managed and eventually lost (Taraba State University, 2023; Bello & Muhammad, 2021).

### Societal Stigma and the Hierarchy of Research

The status of TVET in Nigeria is further undermined by a deep-seated societal perception that vocational education is for the 'academically weak' or a 'last resort' (Ayonmike et al., 2015; Uduafemhe, 2021). This perception creates a hierarchy of research where university-based studies are viewed as 'superior' to those coming from polytechnics, despite polytechnics being the bedrock of technical innovation (Asibeluo, 2015 ). Studies comparing research behaviour between university and polytechnic lecturers in southeast Nigeria revealed that university lecturers exhibit more positive research behaviour and higher productivity than their polytechnic counterparts (Comparative Research Study, 2021). Polytechnic graduates (HND holders) frequently face discrimination in the workplace, often forced to work under university graduates regardless of practical competence (Asibeluo, 2015 ). This institutionalised bias discourages polytechnic researchers from pursuing rigorous empirical studies, as the rewards are significantly lower than those in the university system (Comparative Research Study, 2021; HND Discrimination Study, 2020 ).

### Pedagogical Empirical Interventions: A Glimmer of Rigour

Despite the overwhelming systemic barriers, there are instances of rigorous empirical research that offer a roadmap for reform (Bakare et al., 2023 ; Edidiong et al., 2024 ). These studies often employ experimental or quasi-experimental designs to test psychological or pedagogical interventions in TVET settings (Agbaje et al., 2022 ). For example, a study on the effectiveness of Rational Emotive Behaviour Therapy (REBT) for improving school engagement among pre-service TVET teachers used a randomised control group design (Agbaje et al., 2022). The findings indicated a significant increase in engagement scores at post-test for the treatment group, demonstrating the potential for evidence-based psychological interventions to address student disengagement (Agbaje et al., 2022 ). Another significant empirical effort involved the evaluation of TVET programmes using the Kirkpatrick model, which assesses training across four levels: Reaction, Learning, Behaviour, and Outcome (Edidiong et al., 2024).

**Table 5:** *Kirkpatrick Model Evaluation in a Nigerian Polytechnic*

Level of Evaluation	Finding/Result	Statistical Indicator
Reaction	Adequate/Positive	High stakeholder agreement (Edidiong et al., 2024)
Learning	Adequate	High respondent agreement (Edidiong et al., 2024)
Behaviour	Adequate	Students reported habit changes (Edidiong et al., 2024)
Outcome/Impact	No significant influence	Adjusted $R^2 = -0.005, F = 0.363, p = 0.780$ (Edidiong et al., 2024)

The regression analysis revealed that while reaction, learning, and behaviour were adequate, they did not significantly influence the actual outcome or result of the TVET programme (Edidiong et al., 2024). This is a critical empirical understanding, which suggests that even when 'education' happens, it is not translating into 'economic impact' or 'employability' (Edidiong et al., 2024).

## Conclusions

This critical appraisal set out to interrogate a fundamental question: To what extent can technological research within Nigeria's Technical and Vocational Education and Training (TVET) sector be considered genuinely empirical? The evidence synthesized across the preceding sections compels a response that is necessarily qualified and, in many respects, deeply cautionary. While the procedural architecture of Nigerian technological research, its adherence to the formalities of hypothesis formulation, data collection, and statistical analysis, appears to align with the conventions of the empirical tradition, the substantive integrity of that research is systematically compromised by a confluence of structural, methodological, and ethical failures (Faculty of Education UNN, 2018; Global Publication House, 2025; Jega, 2017).

The preceding analysis has demonstrated that the empirical authenticity of Nigerian technological research is undermined at multiple interdependent levels. Epistemologically, the field suffers from a decoupling of inquiry from its material substrate, wherein research methods have become detached from the technical reality they purport to investigate. Methodologically, the dominance of the descriptive survey, exceeding 90 per cent of studies in some faculties, has produced a 'mono-culture' that privileges the documentation of perception over the observation of practice, effectively transforming technological research into a sociological exercise (Faculty of Education UNN, 2018; Uduafemhe, 2021). This methodological inertia is not merely a matter of intellectual preference but is structurally reinforced by infrastructural decay that renders experimental observation impossible (Ayonmike et al., 2015; New Telegraph, 2026), by a political economy of research funding that forces methodological compromise (Global Publication House, 2025), and by an ethical crisis in which approximately one in five researchers admits to fabrication, falsification, or plagiarism (Agbaje et al., 2013; Global Publication House, 2025).

The consequence of these intersecting failures is a research enterprise that produces what may be termed 'simulated empiricism', scholarly outputs that bear the formal hallmarks of empirical inquiry but are, in substance, disconnected from the observable reality of technical practice. Nigerian technological research frequently operates within a 'ghost empiricism,' collecting data that relates to obsolete equipment, simulated environments, or historical realities rather than the contemporary industrial frontier (Ayonmike et al., 2015; Sylvester, 2021). Even where rigorous interventions are attempted, as demonstrated by Kirkpatrick model evaluations, the finding that pedagogical success fails to translate into economic impact underscores a profound disconnection between academic output and industrial outcome (Edidiong et al., 2024).

For technological research in Nigeria to move from this condition of simulated empiricism toward what may be termed 'materialist empiricism', inquiry genuinely grounded in the observation of and intervention in technical reality, a fundamental structural realignment is imperative. This realignment must proceed along several interconnected axes. First, a deliberate methodological shift is required, wherein the academic community de-emphasises the descriptive survey in favour of experimental, quasi-experimental, and longitudinal designs capable of establishing causal relationships and tracking competency development over time (Faculty of Education UNN, 2018). Second, infrastructural rehabilitation must be prioritised,

with government fulfilling its commitments under the National Integrated Infrastructure Master Plan (NIIMP) and establishing a dedicated Special Research Trust Fund specifically targeted at equipping technical workshops and laboratories (Global Publication House, 2025; National Communications Commission, 2024). Third, ethical fortification demands mandatory research ethics training at both postgraduate and faculty levels, alongside the provision of institutional subscriptions to plagiarism detection software to ensure the integrity of scholarly output (Agbaje et al., 2013; Okonta & Rossouw, 2014; Opesanwo & Anwana, 2023). Fourth, industry-academia synthesis must become the organising principle of research agenda-setting, ensuring that empirical inquiry is co-designed with industrial partners and that findings are oriented toward practical application and economic impact (Bakare et al., 2023). Finally, strategic adoption of emerging technologies, including artificial intelligence for research management and blockchain for verifiable credentialing and assessment, offers pathways for Nigeria to bypass certain traditional logistical barriers and enhance the transparency and efficiency of its research enterprise (Edidiong et al., 2024; Global Publication House, 2025).

The crisis of relevance that has historically plagued Nigerian technology education is, at its core, a crisis of empiricism. For the technology educator and the technological researcher alike, the imperative is clear: only by grounding inquiry in the rigorous, ethical, and material observation of technical reality can the scholarly enterprise hope to contribute to a national transformation that is not merely theoretical but industrially tangible and economically consequential. The restoration of empirical authenticity in Nigerian technological research is therefore not an abstract academic concern but a fundamental precondition for the sector's capacity to fulfil its mandate as a catalyst for sustainable development, industrialisation, and meaningful participation in the Fourth Industrial Revolution.

### **Recommendations**

Based on the foregoing critical appraisal of empirical authenticity in Nigerian technological research, the following recommendations are proffered:

1. Faculties of education and technology in Nigerian universities and polytechnics should institute policy reforms that discourage the over-reliance on descriptive survey designs. Postgraduate supervision and examination boards ought to prioritise experimental, quasi-experimental, and longitudinal methodologies, particularly for doctoral theses, to ensure that technological research engages directly with the observation of practice and the measurement of competency development over time.
2. The Federal Government, in collaboration with the Tertiary Education Trust Fund (TETFund), should establish a special-purpose intervention fund explicitly allocated to the rehabilitation and equipping of technical workshops and laboratories. This initiative must be aligned with the National Integrated Infrastructure Master Plan (NIIMP) and should prioritise institutions demonstrating capacity for experimental research, thereby providing the material substrate necessary for genuine empirical inquiry.
3. All postgraduate programmes in technology-related disciplines should incorporate mandatory, credit-bearing coursework in research ethics. Furthermore, institutions must provide free, institution-wide access to plagiarism detection software and enforce strict penalties for verified cases of fabrication, falsification, and plagiarism. Regular ethics audits should be conducted by university research offices to monitor compliance and restore confidence in Nigerian academic output.

4. Universities and polytechnics should formalise memoranda of understanding with relevant industries to co-design research agendas, share facilities, and facilitate the joint supervision of student projects focused on solving real-world technical problems. Such partnerships should be incentivised through tax rebates for participating industries and recognition in university accreditation exercises, ensuring that research findings are oriented toward practical application and economic impact.
5. Nigerian TVET institutions should leverage emerging technologies, including artificial intelligence for research design and data analysis, and blockchain for secure, verifiable storage of theses and publications. Investment in reliable internet infrastructure and cloud-based research platforms will enable researchers to access global databases, participate in international collaborations, and bypass certain logistical barriers imposed by physical infrastructural deficits

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# Edible Coatings and Nanoencapsulation as Nutritional preservation tools: A review

Fashanu, T. A.<sup>1</sup>, Bamishaiye, E. I.<sup>2</sup>, & Onyegbula, A.F<sup>3</sup>

<sup>1,2,3</sup>Perishable Crop Research Department, Nigerian Stored Products Research Institute (NSPRI), Ilorin, Kwara State, Nigeria

Email: [bamishaiyeei@nspri.gov.ng](mailto:bamishaiyeei@nspri.gov.ng)

## ABSTRACT

*Global postharvest losses of fresh fruits and vegetables are estimated to range from 20 to 50%, with nutritional degradation frequently preceding visible spoilage. The loss of ascorbic acid, carotenoids, polyphenols, B-vitamins, and essential minerals between harvest and consumption represents both an economic burden and a serious public health concern, particularly in sub-Saharan Africa where dietary micronutrient deficiency is endemic. Edible coatings and nanoencapsulation have emerged as complementary, food-grade postharvest technologies capable of retarding nutrient degradation, extending shelf life, and enhancing the bioavailability of health-promoting compounds in both fresh and minimally processed horticultural produce. This review examines the biochemical basis of postharvest nutrient loss, the mechanistic actions and classification of edible coatings, the diversity of nanoencapsulation systems and their physicochemical principles, documented evidence of nutritional preservation efficacy across a range of horticultural crops and treatment strategies, and the prevailing regulatory landscape governing commercial deployment. Findings from recent peer-reviewed literature demonstrate that polysaccharide-based coatings, particularly chitosan and its composites, consistently improve the retention of ascorbic acid, total phenolics, and antioxidant capacity by 25 to 60% relative to uncoated controls under refrigerated or ambient storage conditions. Nanoencapsulation strategies, including nanoemulsions, solid lipid nanoparticles, biopolymer nanoparticles, and liposomes, offer superior protection and targeted gastrointestinal delivery of fat-soluble vitamins and bioactive phytochemicals relative to conventional formulations. Challenges including regulatory gaps for nanofood materials, scalability of production, consumer acceptance, and the need for in vivo bioavailability validation are critically discussed alongside emerging research directions.*

**KEYWORDS:** edible coatings, nanoencapsulation, postharvest nutrition, bioactive compounds, chitosan, nanoemulsion, nutritional biochemistry, food preservation, sub-Saharan Africa

## INTRODUCTION

Fresh horticultural commodities are indispensable contributors to global dietary diversity, supplying essential vitamins, minerals, dietary fibre, and a wide array of health-promoting phytochemicals. Yet these commodities are among the most physiologically active and perishable of all food categories. Harvesting severs the connection to the parent plant and initiates a cascade of biochemical changes driven by continued respiration, ethylene biosynthesis, water loss, and the action of endogenous hydrolytic and oxidative enzymes. Global postharvest losses of fruits and vegetables are estimated at 30 to 50% in developing nations and 10 to 30% in developed economies (Yadav et al., 2022). Critically, nutritional degradation often occurs before physical spoilage is apparent, meaning that commercially acceptable produce may deliver significantly reduced nutritional value to the consumer.

Conventional postharvest interventions, including cold storage, modified atmosphere packaging, and chemical fungicides, address aspects of quality preservation but are constrained by high infrastructure requirements, environmental concerns, residue regulations, and in the African context, inadequate cold chain continuity. Consumer and regulatory pressure has intensified demand for non-chemical, biodegradable, and sustainable preservation strategies. Edible coatings and nanoencapsulation represent two of the most scientifically substantiated and commercially promising responses to this demand (Chen et al., 2022; Krishnan & Subramanian, 2025).

Edible coatings are thin, continuous layers of food-grade polymers applied to produce surfaces that function as selective gas, moisture, and microbial barriers. Nanoencapsulation involves the entrapment of bioactive nutrients within nanoscale carrier matrices to protect against environmental degradation and improve their bioavailability in the gastrointestinal tract. Although these technologies operate through different mechanisms and at different scales, they share the overarching goal of maintaining nutritional integrity from harvest to human consumption.

The importance of these technologies is particularly acute for crops characteristic of African food systems. Bamishaiye and Bamishaiye (2011) documented the rich nutritional composition of tiger nut (*Cyperus esculentus*), including substantial concentrations of vitamin E, oleic acid, potassium, and phosphorus, establishing its potential as a functional food in the African context. Similarly, work by Bamishaiye et al. (2011) on the effects of thermal processing on the mineral and vitamin C content of *Hibiscus sabdariffa* drinks demonstrated that even modest heat exposure results in measurable micronutrient losses, highlighting the need for preservation interventions that account for the biochemical sensitivity of nutritionally valuable indigenous crops. These examples underscore the broader challenge that faces postharvest technologists and nutritional biochemists working in tropical environments, where ambient temperatures accelerate nutrient catabolism and infrastructure limitations constrain access to cold chain solutions.

This review synthesises current literature, with emphasis on studies published from 2021 onwards, on edible coatings and nanoencapsulation as nutritional preservation tools. It evaluates mechanisms of action, comparative efficacy, regulatory considerations, and future directions, with specific attention to the implications for African food systems.

## **2. Biochemical Basis of Postharvest Nutrient Loss**

### **2.1 Respiration, Ethylene, and Metabolic Deterioration**

The respiratory metabolism of harvested produce consumes carbohydrate reserves and organic acids to generate ATP, carbon dioxide, and water, simultaneously producing heat that accelerates tissue senescence. Climacteric fruits such as mango (*Mangifera indica*), banana (*Musa acuminata*), and papaya (*Carica papaya*) exhibit a pronounced ethylene-triggered respiratory climacteric that dramatically accelerates ripening, softening, and pigment degradation. Non-climacteric fruits such as strawberry (*Fragaria x ananassa*) and citrus lack this ethylene surge but undergo progressive tissue senescence driven by continued aerobic catabolism. In both categories, the diversion of metabolic substrates from cell maintenance to respiratory catabolism accelerates the breakdown of organelles, membranes, and the biochemical matrices in which vitamins and polyphenols are stored.

Ethylene itself exerts direct effects on nutrient composition by stimulating the expression of cell wall-degrading enzymes, including polygalacturonase, cellulase, and pectin methyl esterase, that degrade the structural polysaccharides of cell walls and disrupt subcellular compartmentalisation. The resulting leakage of vacuolar contents exposes previously

sequestered ascorbic acid to cytosolic oxidative conditions, while the disruption of chromoplast membranes accelerates carotenoid photo-oxidation (Martins et al., 2024).

## 2.2 Oxidative Degradation of Vitamins and Phytochemicals

Ascorbic acid (vitamin C) is among the most nutritionally and biochemically labile of all postharvest micronutrients. Its oxidation proceeds through two successive reactions: the reversible oxidation of L-ascorbic acid to dehydroascorbic acid, catalysed by ascorbate oxidase and facilitated by molecular oxygen; and the irreversible hydrolysis of dehydroascorbic acid to 2,3-diketogulonic acid and its further catabolites. At ambient tropical temperatures (25 to 35 degrees Celsius), losses of 40 to 60% of the initial ascorbic acid content have been reported in fresh-cut tropical fruits within 24 to 48 hours of processing, while even refrigerated storage results in substantial losses over 7 to 14 days (Saleem et al., 2021). These observations are consistent with the documented losses in processed Hibiscus sabdariffa beverages reported by Bamishaiye et al. (2011), where boiling-mediated oxidation and leaching significantly reduced both mineral and vitamin C content.

Carotenoids, including beta-carotene, lycopene, zeaxanthin, and lutein, undergo both enzymatic and non-enzymatic oxidative degradation during postharvest storage. Non-enzymatic autoxidation proceeds via a free radical chain mechanism initiated by reactive oxygen species (ROS), leading to chain cleavage and the formation of apocarotenoids and volatile degradation products. Enzymatic degradation is mediated primarily by lipoxygenase (LOX) and carotenoid cleavage dioxygenases, whose activities increase during senescence-induced membrane disruption. Geometric isomerisation from the nutritionally active all-trans form to less bioavailable cis isomers occurs under heat and light exposure, representing a loss of nutritional function even without molecular degradation (Duguma, 2022).

Polyphenols, including flavonoids, anthocyanins, chlorogenic acids, and procyanidins, are among the most abundant and nutritionally significant bioactives in fresh produce. Their postharvest degradation is dominated by enzymatic oxidation through the action of polyphenol oxidase (PPO) and peroxidase (POD). These copper-containing oxidases catalyse the hydroxylation of monophenols and the subsequent oxidation of ortho-diphenols to ortho-quinones, highly reactive electrophilic species that polymerise to form brown-coloured melanin-like pigments. Browning is thus simultaneously a visible quality defect and a direct measure of polyphenol loss. PPO and POD activities are rapidly induced by mechanical injury, chilling stress, and the senescence-associated disruption of cell compartmentalisation (Li et al., 2024).

## 2.3 Mineral Bioaccessibility and Structural Deterioration

While total mineral content is relatively resistant to biological degradation, postharvest deterioration significantly affects mineral bioaccessibility. As cellular integrity is lost, minerals associated with organelles and cell wall pectin matrices are released into exudate, leaching into washing and processing water. Furthermore, the progressive acidification of senescent tissue due to organic acid catabolism and the formation of insoluble mineral-polyphenol complexes reduces the proportion of iron, zinc, and calcium present in bioavailable forms. These effects are compounded in minimally processed produce, where cutting exposes far greater surface areas to oxidative and microbial attack. The degradation of cell wall polysaccharides by pectinolytic enzymes also reduces the dietary fibre quality of stored produce, with implications for its role in promoting mineral absorption in the gastrointestinal tract.

### 3. Edible Coatings: Classification, Composition, and Mechanisms

#### 3.1 Definition, Classification, and Key Materials

Edible coatings are thin, continuous, food-grade films applied directly to the surface of fresh or minimally processed produce, either by dipping, spraying, or brushing. They are distinguished from edible films in that they are applied in situ rather than cast separately and wrapped around the product; ideal coating thickness is defined as 25 millimetres or less (Nain et al., 2021). The global market value of edible coatings and films in the fruit and vegetable sector was estimated at USD 754 million in 2021 and is projected to reach USD 1.36 billion by 2030, reflecting exponential growth in their commercial adoption (Krishnan & Subramanian, 2025). Table 1 presents the principal categories of edible coating materials currently in research and commercial use.

**Table 1: Classification, mechanisms, and limitations of principal edible coating types used in postharvest nutritional preservation**

Coating Category	Key Materials	Primary Preservation Mechanism	Key Nutrients Protected	Limitation
<b>Polysaccharide-based</b>	Chitosan, alginate, starch, carrageenan, pectin, cellulose derivatives	Selective gas barrier; moisture retention; antimicrobial activity via cationic disruption of microbial membranes	Vitamin C, polyphenols, anthocyanins, B-vitamins	Moisture sensitivity; reduced O <sub>2</sub> barrier at high RH
<b>Protein-based</b>	Whey protein, soy protein, zein, casein, gelatin	Excellent O <sub>2</sub> barrier at low RH; structural integrity; antioxidant carrier capacity	Vitamins A, D, E, K; carotenoids; polyunsaturated fatty acids	pH/ionic strength sensitivity; dairy allergen concerns
<b>Lipid-based</b>	Beeswax, carnauba wax, shellac, acetylated monoglycerides	Superior water vapour barrier; gloss enhancement; ethylene management	Fat-soluble vitamins; essential oils	Poor CO <sub>2</sub> control; off-flavour risk; opacity
<b>Composite / Active</b>	Chitosan-beeswax, alginate-whey protein, pectin-essential oil, protein-polysaccharide blends	Synergistic gas, moisture, and microbial barriers; simultaneous antioxidant and antimicrobial delivery	Multiple vitamins, polyphenols, carotenoids, minerals	Complex formulation; higher production cost

##### 3.1.1 Polysaccharide-Based Coatings

Among polysaccharide coatings, chitosan derived from the partial deacetylation of chitin found in crustacean exoskeletons and fungal cell walls has received the most extensive research attention. Chitosan is cationic at physiological pH, enabling electrostatic interaction with the negatively charged surface components of microbial cell membranes, disrupting membrane integrity and causing leakage of intracellular contents. This broad-spectrum antimicrobial activity, combined with its film-forming capacity, oxygen barrier properties, and wound-healing stimulation in plant tissue, renders it uniquely functional among postharvest coating agents. Concentrations of 0.5 to 3.0% (w/v) are most commonly employed; Saleem et al. (2021) demonstrated that 1% chitosan coating combined with 1% ascorbic acid significantly maintained vitamin C, total phenolics, and antioxidant enzyme activities in strawberries stored at 4 degrees Celsius for 15 days, suppressing PPO and POD activities and reducing malondialdehyde accumulation compared to uncoated controls.

Sodium alginate, a linear anionic polysaccharide extracted from brown seaweeds such as *Macrocystis pyrifera* and *Laminaria digitata*, forms strong, transparent gels in the presence of divalent cations, particularly calcium ions. This ionic gelation mechanism allows in situ coating formation on produce surfaces through sequential dipping in alginate and calcium chloride solutions. Alginate coatings exhibit favourable oxygen and carbon dioxide permeabilities, creating a mild modified atmosphere within the coated tissue that retards aerobic catabolism. Jurić et al. (2023) applied chitosan-based layer-by-layer coatings to mandarin fruit and reported significantly better preservation of bioactive compounds and organic acids compared to conventional single-layer coatings, demonstrating the advantage of electrostatic multilayer assembly for building more robust nutritional barriers. Starch, pectin, carrageenan, carboxymethyl cellulose, and guar gum have also been extensively studied as coating bases, offering region-specific advantages in terms of availability, cost, and compatibility with local produce.

### **3.1.2 Protein-Based Coatings**

Protein-based coatings, including those fabricated from whey protein isolate, soy protein isolate, casein, zein (corn prolamin), and gelatin, provide distinct barrier properties compared to polysaccharides. At low relative humidity, protein films exhibit exceptional oxygen barrier performance owing to the dense, hydrophilic network of intermolecular disulfide bonds, hydrogen bonds, and hydrophobic interactions that form during film drying. This oxygen barrier property is particularly valuable for protecting lipid-soluble vitamins such as vitamin E and carotenoids from peroxidative degradation. Protein coatings can also be crosslinked with transglutaminase, genipin, or citric acid to enhance their mechanical and moisture resistance. The incorporation of antioxidant peptides generated by controlled hydrolysis of whey proteins further augments their nutritional preservation function beyond simple gas barrier effects.

### **3.1.3 Lipid-Based and Composite Coatings**

Lipid-based coatings, including beeswax, carnauba wax from *Copernicia prunifera*, shellac, and acetylated monoglycerides, are highly effective water vapour barriers owing to the hydrophobic nature of their constituent fatty acids and wax esters. Commercial wax coatings have been applied to citrus, apple, and mango for several decades to reduce transpiration and improve gloss. However, the limitation of lipid coatings in controlling CO<sub>2</sub> permeability can lead to anaerobic conditions at high coating concentrations, inducing off-flavour production through fermentative metabolism. Composite coatings that integrate polysaccharide and lipid or protein components address multiple quality parameters simultaneously. Wang et al. (2024) reported that carboxymethyl chitosan coatings infused with linalool-loaded beta-lactoglobulin nanoparticles significantly inhibited browning, preserved phenolic content, and extended the shelf life of fresh-cut apples by up to two-fold, exemplifying the synergistic potential of protein-polysaccharide-lipid composite systems.

## **3.2 Mechanisms of Nutritional Preservation**

### **3.2.1 Modified Atmosphere and Gas Barrier Effects**

By functioning as a selective semi-permeable membrane, edible coatings reduce the rate of O<sub>2</sub> diffusion into the produce and CO<sub>2</sub> diffusion outward, creating a microatmosphere at the produce surface characterised by lower oxygen and higher carbon dioxide partial pressures compared to ambient air. This modified atmosphere has several biochemical consequences relevant to nutritional preservation. Reduced O<sub>2</sub> availability decreases the substrate supply for ascorbate oxidase and PPO, slowing vitamin C and polyphenol oxidation respectively. Elevated CO<sub>2</sub> competes with O<sub>2</sub> at cytochrome c oxidase in the mitochondrial electron transport chain, reducing overall respiration rate and the consequent depletion of metabolic

substrates that would otherwise drive senescence-associated degradation of cell structure and nutritional composition (Nain et al., 2021; Martins et al., 2024).

### **3.2.2 Moisture Retention and Structural Integrity**

Transpiration-driven moisture loss from harvested produce is not merely a commercial weight loss problem but a biochemical one. As cells lose water, the concentration of prooxidant metal ions increases, the physical compartmentalisation of reactive substrates and their catalytic enzymes is disrupted by cytoplasmic condensation, and membrane fluidity decreases, promoting phase transitions that impair lipid bilayer integrity. Edible coatings reduce the rate of water vapour transmission through the produce surface, maintaining cell turgor and thereby preserving the physical separation between PPO and its polyphenol substrates in vacuoles and the apoplast. Tussaadah et al. (2025) demonstrated that a chitosan-mango seed starch-orange peel essential oil composite coating reduced weight loss by 61.27% and retained 39.60% vitamin C in coated strawberries compared to only 26.40% in uncoated controls after 15 days of refrigeration, extending commercial shelf life from 6 to 13 days.

### **3.2.3 Antimicrobial Activity and Enzymatic Inhibition**

Microbial colonisation of postharvest produce accelerates nutritional deterioration through direct catabolism of vitamins and polyphenols by microbial oxidases and hydrolases, and through the stimulation of plant defence responses that redirect metabolic resources away from nutritional compound synthesis and maintenance. Chitosan coatings exert their antimicrobial effect primarily through membrane disruption but also through chelation of essential metal ions from microbial cell walls and the inhibition of mRNA and protein synthesis at higher concentrations. The incorporation of essential oils, including thymol, carvacrol, linalool, and eugenol, into coating matrices provides additional volatile antimicrobial compounds that act in the gas phase, inhibiting surface mould and bacteria without direct contact (Guo et al., 2023). Kumarihami et al. (2022) demonstrated that the inclusion of nano-TiO<sub>2</sub> in chitosan coatings for blueberry produced superior suppression of PPO and POD activities and better retention of anthocyanins and vitamin C compared to chitosan coatings alone, suggesting that photocatalytic ROS generation by nano-TiO<sub>2</sub> under visible light may contribute to antimicrobial and enzyme-inhibitory effects at the produce surface.

### **3.2.4 Antioxidant Delivery and ROS Scavenging**

A particularly powerful application of edible coatings is as carriers for exogenous antioxidants that actively intercept ROS at the produce surface, providing a first line of chemical defence that supplements the produce's own antioxidant enzyme systems. Vitamin E (alpha-tocopherol), ascorbic acid, rosemary extract, green tea polyphenols, and plant-derived essential oils with demonstrated radical scavenging activity have all been successfully incorporated into coating matrices. Zambrano-Zaragoza et al. (2014) showed that nano-coatings containing alpha-tocopherol and xanthan gum significantly delayed browning and preserved the phenolic content of fresh-cut Red Delicious apple, with the nanoscale formulation providing superior antioxidant distribution across the produce surface compared to conventional coating applications. Zhou et al. (2022; 2024) further elucidated the mechanism underlying ascorbic acid-chitosan coating efficacy in papaya, demonstrating that the combined treatment enhanced tricarboxylic acid (TCA) cycle activity and the pentose phosphate pathway, maintained ATP and NADPH concentrations, and upregulated ROS-scavenging enzyme activities (SOD, CAT, POD, APX), collectively sustaining metabolic homeostasis and nutritional quality during postharvest storage.

## 4. Nanoencapsulation: Systems, Mechanisms, and Nutritional Applications

### 4.1 Overview and Classification of Nanoencapsulation Systems

Nanoencapsulation involves the entrapment of a bioactive compound or nutrient, the core material, within a protective carrier, the wall or shell material, at a nanometre scale, typically ranging from 1 to 1000 nm (Sultana et al., 2022). At this scale, several physicochemical phenomena emerge that are absent at the microscale: dramatically increased surface area-to-volume ratios, enhanced surface reactivity, modified solubility, altered crystallinity, and unique optical and mechanical properties. In the context of food and nutritional science, these properties translate into superior encapsulation efficiency, improved core material stability, enhanced dispersion in aqueous food matrices, and fundamentally improved gastrointestinal bioavailability compared to equivalent macroscale formulations. Table 2 classifies the principal nanoencapsulation systems applicable to nutritional preservation.

**Table 2: Principal nanoencapsulation systems used in food nutritional preservation and their key characteristics**

System	Particle Size	Wall / Carrier Material	Nutrients / Bioactives Encapsulated	Notable Advantage
<b>Nanoemulsion</b>	20-200 nm	Lecithin, Tween 80, saponins	Vitamins A, D, E, K; omega-3 fatty acids; carotenoids; essential oils	Dramatically enhanced bioaccessibility of fat-soluble nutrients; transparent in aqueous systems
<b>Solid lipid nanoparticles (SLN)</b>	50-400 nm	Glycerides, triglycerides, fatty acids	Fat-soluble vitamins, curcumin, lycopene, beta-carotene	Sustained, controlled release; solid matrix offers superior protection vs liquid emulsions
<b>Biopolymer nanoparticles</b>	100-500 nm	Chitosan, zein, whey protein, casein micelles	Folate, vitamin C, polyphenols, iron, zinc, quercetin	pH- and enzyme-responsive release; fully food-grade; excellent gut stability
<b>Liposomes</b>	50-1000 nm	Phospholipids, cholesterol	Vitamin C, B-complex, antioxidants, curcumin, minerals	Amphiphilic structure enables simultaneous hydrophilic and lipophilic encapsulation; mimics biological membranes
<b>Cyclodextrin inclusion complexes</b>	0.7-0.8 nm cavity	alpha-, beta-, gamma-cyclodextrin	Flavour volatiles, folate, carotenoids, vitamins D and E	Molecular-level entrapment; stabilises thermolabile and photolabile nutrients; approved food-grade status
<b>Nanostructured lipid carriers (NLC)</b>	100-500 nm	Blend of solid + liquid lipids	Lycopene, astaxanthin, omega-3 PUFA, vitamin E	Higher drug-loading than SLN; reduced crystallinity extends release

## **4.2 Physicochemical Mechanisms of Enhanced Stability and Bioavailability**

### **4.2.1 Protection from Degradative Conditions**

The primary physical mechanism of nanoencapsulation-mediated stabilisation is the creation of a tortuous diffusion path for oxygen, light, and prooxidant species through the wall material surrounding the encapsulated core. In a dense biopolymer nanoparticle matrix, the mean free path of a diffusing oxygen molecule is dramatically extended relative to an unprotected solution, reducing the rate of oxidative reactions proportionally. For vitamin D<sub>3</sub>, which is susceptible to isomerisation under UV exposure, encapsulation within chitosan or casein micelle nanoparticles has been shown to maintain biological activity through simulated gastrointestinal digestion conditions that would otherwise destroy the free vitamin (Sultana et al., 2022). Similarly, nanoencapsulated beta-carotene in solid lipid nanoparticles retained over 85% of its initial concentration after 90 days of storage at 25 degrees Celsius, compared to less than 40% for a conventional emulsion under identical conditions.

Chemical stabilisation mechanisms also operate at the molecular level within nanocarriers. The hydrophobic interior of lipid nanoparticles and nanoemulsions creates a microenvironment that sequesters fat-soluble vitamins and carotenoids from the aqueous phase where metal-catalysed oxidation occurs. The high packing density of solid lipid nanoparticle matrices at physiological temperatures limits the mobility of encapsulated molecules, reducing the frequency of intermolecular encounters that drive degradation reactions. In protein nanoparticles, the specific secondary and tertiary protein structures created during nanoparticle assembly can shield encapsulated polyphenols or vitamins from direct contact with prooxidant species through steric exclusion (Shahidi & Han, 1993; Sultana et al., 2022).

### **4.2.2 Enhanced Gastrointestinal Bioavailability**

Beyond stability during storage, nanoencapsulation offers transformative improvements in the gastrointestinal bioavailability of nutrients that are inherently poorly absorbed in their free form. Fat-soluble vitamins (A, D, E, K) and carotenoids require micellarisation in bile salt-lecithin mixed micelles before intestinal absorption can occur. This process is rate-limited by the surface area available for pancreatic lipase attack. Nanoemulsions present fat-soluble vitamins within oil droplets of 20 to 200 nm diameter, providing enormously greater interfacial surface area than macroscale emulsions or food matrices, dramatically accelerating lipase-mediated micellarisation and absorption. In vivo studies have reported 3- to 5-fold increases in the oral bioavailability of vitamin E and lycopene from nanoemulsion formulations compared to conventional lipid vehicles (Sultana et al., 2022).

For hydrophilic nutrients, biopolymer nanoparticles offer targeted delivery by protecting the encapsulated compound from degradation in the low-pH gastric environment and releasing it selectively in the higher-pH small intestinal milieu, where absorption is most efficient. Chitosan nanoparticles, which are cationic, can adhere to the negatively charged mucosal epithelium through electrostatic interactions (mucoadhesion), increasing the residence time of encapsulated nutrients at the absorption site and their effective concentration gradient across the intestinal epithelium. Casein micelles, which naturally function as calcium and phosphate delivery vehicles in bovine milk, have been extensively repurposed as food-grade carriers for vitamin D<sub>3</sub>, curcumin, and polyphenols, leveraging their structural similarity to physiological mineral transport vehicles to improve nutrient uptake efficiency (Sultana et al., 2022; Patel, 2017).

### **4.3 Nutrient-Specific Nanoencapsulation Applications**

#### **4.3.1 Vitamin C**

Ascorbic acid presents a particular challenge for encapsulation owing to its high water solubility, susceptibility to both oxidative and thermal degradation, and instability in neutral and alkaline pH environments. Biopolymer nanoparticles, particularly those fabricated from chitosan-alginate, whey protein, and cellulose-derived materials, have been used to encapsulate ascorbic acid and achieve encapsulation efficiencies of 70 to 95%, with significantly improved stability under accelerated storage conditions. Luo et al. (2024) demonstrated that chitosan-apple essence microencapsulation coating incorporating ascorbic acid effectively controlled browning and preserved vitamin C in fresh-cut apple while simultaneously maintaining flavour volatile profiles, illustrating the dual functionality of combined antioxidant-antimicrobial encapsulation systems.

#### **4.3.2 Carotenoids and Fat-Soluble Vitamins**

Lycopene from tomato (*Solanum lycopersicum*) and beta-carotene from orange-fleshed fruits and vegetables are among the most biomedically significant carotenoids, with established associations with reduced risk of cardiovascular disease, macular degeneration, and certain cancers. Their encapsulation within solid lipid nanoparticles, nanostructured lipid carriers (NLCs), or protein-stabilised nanoemulsions consistently improves both storage stability and gastrointestinal bioaccessibility. NLCs, which incorporate a mixture of solid and liquid lipids in proportions that disrupt the crystalline packing of the solid lipid phase, achieve higher loading capacity and more controlled release than pure solid lipid matrices (Sultana et al., 2022). Vitamin E encapsulated within alpha-tocopherol-loaded zein nanoparticles applied as surface coatings on apple slices has demonstrated potent antioxidant delivery and delayed browning, with efficacy superior to free vitamin E solutions (Zambrano-Zaragoza et al., 2014).

#### **4.3.3 Polyphenols and Anthocyanins**

The biological activity of dietary polyphenols, including quercetin, resveratrol, chlorogenic acid, curcumin, and anthocyanins, is substantially attenuated by their poor water solubility, chemical instability at physiological pH, extensive first-pass metabolism, and low intestinal permeability. Nanoencapsulation within cyclodextrin inclusion complexes, chitosan nanoparticles, or zein-casein composite nanoparticles has been shown to improve the aqueous solubility of quercetin and curcumin by 10- to 100-fold, protect anthocyanins from pH-dependent colour change and degradation, and extend the plasma half-life of encapsulated polyphenols by reducing first-pass hepatic metabolism. The application of these systems to postharvest produce surfaces or processing environments could both reduce polyphenol degradation during storage and improve the bioavailability of the polyphenols that are successfully preserved to the point of consumption.

### **4.4 Comparative Efficacy Across Horticultural Produce**

Table 3 presents evidence from recent peer-reviewed studies comparing nutritional outcomes in produce treated with edible coatings or nanoencapsulation-based treatments versus untreated controls.

**Table 3: Comparative nutritional preservation efficacy of edible coatings and nanoencapsulation treatments across selected horticultural produce (2021-2025)**

Produce	Treatment Applied	Nutrient / Quality Parameter	Key Outcome	Reference
<b>Strawberry (<i>Fragaria x ananassa</i>)</b>	Chitosan (1%) + ascorbic acid (1%) coating	Vitamin C, total phenolics, antioxidant activity	Significantly higher ascorbic acid and antioxidant retention over 15 days cold storage vs. control	Saleem et al. (2021)
<b>Papaya (<i>Carica papaya</i>)</b>	Ascorbic acid (1.5%) + chitosan (1%) composite coating	Vitamin C, total phenols, antioxidant enzymes (SOD, CAT, POD)	Delayed senescence; maintained TCA cycle homeostasis; extended shelf life	Zhou et al. (2022; 2024)
<b>Blueberry (<i>Vaccinium corymbosum</i>)</b>	Chitosan + nano-TiO <sub>2</sub> composite coating	Vitamin C, anthocyanins, total polyphenols, flavonoids	Superior retention of all nutritional markers vs chitosan alone; delayed antioxidant capacity decline at 0 degrees C	Kumarihami et al. (2022)
<b>Mango (<i>Mangifera indica</i>)</b>	Chitosan + aloe vera composite coating	Beta-carotene, ascorbic acid, total phenolics	Significantly higher carotenoid and vitamin C retention; reduced weight loss; extended marketable shelf life	Kumar et al. (2023)
<b>Fresh-cut apple (<i>Malus domestica</i>)</b>	Carboxymethyl chitosan + linalool-loaded beta-lactoglobulin nanoparticles	Browning index, total phenolics, antioxidant activity, firmness	Inhibited PPO-driven browning; preserved phenolic content; extended shelf life by up to 2-fold	Wang et al. (2024)
<b>Strawberry (<i>Fragaria</i> sp.)</b>	Chitosan + mango seed starch + orange peel essential oil composite coating	Vitamin C, weight loss, firmness, microbial load	Retained 39.60% vitamin C vs 26.40% in controls after 15 days refrigeration; shelf life extended from 6 to 13 days	Tussaadah et al. (2025)

The evidence assembled in Table 3 illustrates several consistent patterns. Composite chitosan-based coatings that combine a physical barrier with antioxidant and antimicrobial functional additives consistently outperform single-component coatings in nutritional retention. The incorporation of nanoparticles into coating matrices, as exemplified by the chitosan-nano-TiO<sub>2</sub> system for blueberry and the carboxymethyl chitosan-linalool nanoparticle system for fresh-cut apple, provides further enhancement of efficacy beyond what can be achieved with equivalent macroscale formulations. These gains are attributable to the more uniform distribution of active agents across the produce surface and the sustained, controlled release of antioxidants and antimicrobials from nanocarriers over the storage period, rather than the immediate and rapidly depleted activity of conventionally dispersed additives.

## **5. Integration of Edible Coatings and Nanoencapsulation**

The most significant recent development in this field is the convergence of edible coating and nanoencapsulation technologies into unified systems in which the coating matrix serves simultaneously as a structural barrier and as a depot for nanoencapsulated bioactive agents. In these integrated systems, nanoparticles loaded with antioxidants, antimicrobials, or biofortification nutrients are suspended within a biopolymer coating solution and applied to the produce surface. Upon drying, the nanoparticles are immobilised within the coating matrix, from which they gradually release their payload over the storage period through diffusion, swelling, or biodegradation of the wall material.

Wang et al. (2024) exemplified this integrated approach with carboxymethyl chitosan coatings infused with linalool-loaded molten globular beta-lactoglobulin nanoparticles for fresh-cut apple preservation. The dual-function system combined the gas and moisture barrier properties of the chitosan-based coating matrix with the sustained antimicrobial linalool release from protein nanoparticles, achieving superior control of browning, microbial load, and total phenolic content compared to either the coating or the nanoparticles alone. Similarly, Guo et al. (2023) demonstrated that carvacrol-loaded nanoemulsions incorporated into edible coating formulations improved both microbiological safety and physicochemical quality of fresh-cut apples, with the nanoscale droplet size enabling more uniform distribution of the antimicrobial agent across cut surfaces compared to conventional essential oil incorporation.

The selection of an appropriate nanocarrier for integration into a coating matrix is guided by compatibility considerations including the pH and ionic strength of the coating solution, the thermal and shear sensitivity of the nanocarrier during coating preparation, the interaction between the nanocarrier surface and the coating polymer chains, and the desired release profile. Protein nanoparticles and polysaccharide nanoparticles are generally most compatible with polysaccharide-based coating matrices due to their similar surface charge characteristics and hydrophilicity. Lipid nanoparticles require careful stabilisation with food-grade emulsifiers to prevent coalescence within the aqueous coating solution. These formulation challenges represent significant research opportunities for producing next-generation multifunctional coating systems.

## **6. Relevance to African Food Systems and Underutilised Crops**

Africa bears a disproportionate burden of postharvest losses relative to global averages, with some estimates placing fruit and vegetable losses at 40 to 50% of production in sub-Saharan Africa, driven by inadequate cold chain infrastructure, poor road networks, limited access to postharvest technologies, and high ambient temperatures that accelerate biochemical deterioration. These losses translate directly into nutritional insecurity, as fresh produce constitutes a primary source of vitamins and minerals for large segments of the population in countries where food diversity is already constrained by poverty.

The application of edible coatings to commercially important African crops, including mango, banana, papaya, tomato, and leafy vegetables, is technically feasible using locally available biopolymers. Materials such as mucilage from cactus pear (*Opuntia ficus-indica*), gum arabic from *Acacia senegal*, okra (*Abelmoschus esculentus*) mucilage, and Bambara groundnut (*Vigna subterranea*) protein offer regionally accessible, affordable, and food-safe alternatives to imported chitosan and alginate. The documented nutritional richness of underutilised African crops, such as the mineral-dense *Cyperus esculentus* tuber and the vitamin C- and anthocyanin-rich *Hibiscus sabdariffa* calyx (Bamishaiye & Bamishaiye, 2011; Bamishaiye et al., 2011), provides compelling motivation for developing appropriate postharvest coating and encapsulation protocols to preserve these nutrients through the supply chain.

The practical implementation of nanoencapsulation technologies in African postharvest contexts requires particular attention to production cost and the availability of appropriate processing equipment. High-energy methods such as high-pressure homogenisation and ultrasonication, which are standard in sophisticated food manufacturing environments, may be inaccessible to smallholder processors. Low-energy spontaneous emulsification methods, which can produce nanoemulsions using simple mixing equipment, represent a more appropriate technology pathway for low-resource settings. Similarly, spray-drying and freeze-drying for producing biopolymer nanoparticle powders that can be reconstituted on-farm or in small-scale packhouses offer practical routes to nanoencapsulation technology adoption in Africa (Sultana et al., 2022).

## 7. Regulatory Considerations and Consumer Perspectives

The regulatory classification of edible coating materials and nanoencapsulated food ingredients varies substantially across jurisdictions, creating a complex compliance landscape for products intended for international markets. Table 4 provides a comparative overview of the regulatory status of key materials in major jurisdictions relevant to Nigerian and West African food exporters.

**Table 4: Comparative regulatory status of selected edible coating and nanoencapsulation materials across major jurisdictions**

Material / Technology	USA (FDA)	EU (EFSA)	Nigeria (NAFDAC)	Key Regulatory Consideration
<b>Chitosan</b>	GRAS affirmed	Approved (E-number pending)	No specific guideline	Crustacean-derived; allergen declaration legally required in the EU; source and deacetylation degree affect regulatory classification
<b>Sodium alginate</b>	GRAS (21 CFR 184.1011)	E401 approved additive	Accepted as food additive	Widely accepted; seaweed source; acceptable for vegan, halal, and organic certification
<b>Beeswax / Carnauba wax</b>	GRAS (21 CFR 184.1973)	E901 / E903 approved	Accepted; regulated as food additive	Natural origin; compatible with organic labelling; minimal toxicological concern
<b>Whey protein / Zein</b>	GRAS	Approved food ingredients	Accepted	Whey protein requires dairy allergen disclosure; zein (corn prolamins) generally well-tolerated; suitability for celiac

				patients should be verified
<b>Nanoemulsions</b>	Case-by-case GRAS; FDA guidance 2012	Novel food (Regulation EU 2015/2283)	No specific nanofood regulation	Must demonstrate that nanoscale does not alter safety profile; droplet size and composition determine classification; increasing commercial approvals for food-grade surfactant systems
<b>Solid lipid nanoparticles / Biopolymer nanoparticles</b>	Evaluation required; no blanket GRAS	Case-by-case EFSA assessment	No framework	EFSA requires full physicochemical and toxicological characterisation; particle size, surface charge, and dissolution behaviour are critical evaluation parameters; African regulatory capacity for nanotoxicology remains limited

In the United States, the FDA regulates most edible coating materials under the Generally Recognized as Safe (GRAS) framework (Title 21 of the Code of Federal Regulations), with specific provisions for individual polymers and waxes that have long histories of safe food contact use. The EU regulatory environment, governed by Regulations EC 1333/2008 (food additives) and EU 2015/2283 (novel foods), imposes more stringent pre-market assessment requirements, particularly for materials classified as novel based on their physicochemical properties at the nanoscale. EFSA has established that the same material may require separate safety evaluation when in nanoparticulate form if its physicochemical properties differ substantially from the bulk material, a principle with significant implications for nanoencapsulated food ingredients.

In Nigeria, NAFDAC regulates food additives and packaging materials through the Food, Drugs, and Related Products Regulations but has not yet issued specific guidelines for nanomaterials in food applications. This regulatory gap presents both opportunity and risk: opportunity because it does not prevent early adoption of these technologies, and risk because the absence of clear standards may deter investment in product safety characterisation and limit export market access for Nigerian products using nanoencapsulation (Patel, 2017). Engagement with NAFDAC and the African Union's Continental Food Safety Authority framework to develop context-appropriate nanofood regulations represents a critical policy priority.

Consumer acceptance of edible coatings is generally more favourable than that of nanoencapsulation. Coatings derived from natural biopolymers such as aloe vera, chitosan, and plant waxes align well with consumer preference for natural, clean-label produce. The term 'nanoencapsulation,' by contrast, frequently elicits uncertainty among consumers unfamiliar with the food-grade, biodegradable nature of biopolymer nanocarriers. Communication strategies that emphasise the naturally derived composition of these systems, their analogy to naturally occurring nanoscale structures in food (such as casein micelles and cell membrane lipid bilayers), and their demonstrated safety record will be essential for consumer acceptance. Transparent labelling policies that accurately characterise the nature of nanoencapsulated ingredients without inducing unwarranted alarm represent a significant regulatory and marketing challenge (Krishnan & Subramanian, 2025).

## **8. Challenges and Barriers to Large-Scale Adoption**

### **8.1 Production Scalability and Cost**

The production of food-grade nanoemulsions and biopolymer nanoparticles at industrial scale presents substantial technical and economic challenges. High-energy homogenisation methods, including microfluidisers and ultrahigh-pressure homogenisers capable of achieving droplet sizes below 200 nm, require capital equipment investments of USD 50,000 to 500,000 or more and significant maintenance and operational expertise. Even at pilot scale, batch-to-batch variability in nanoparticle size distribution, encapsulation efficiency, and surface charge can compromise product consistency, requiring robust quality control protocols. Spray-drying of nanoparticle dispersions to produce shelf-stable powders introduces additional thermal stress that may reduce the viability of heat-labile encapsulated compounds. Addressing these challenges requires investment in low-energy, scalable production methods and the development of analytical tools appropriate for quality control of nanoparticle-based postharvest products in low-resource settings.

### **8.2 Coating Adhesion and Sensory Impact**

Effective postharvest coating requires adequate adhesion to the heterogeneous, waxy surfaces of many fruits and vegetables, which may be naturally hydrophobic and resistant to aqueous coating solutions. The removal of natural epicuticular waxes during commercial washing procedures, while improving hygiene, also reduces the natural barrier function of the produce surface and increases the challenge of achieving uniform coating coverage. Coating adhesion can be improved through the incorporation of adhesion promoters such as glycerol, sorbitol, or plant-derived emulsifiers that improve wettability of the produce surface, but these additions must be balanced against their impact on coating permeability and sensory properties. Coatings that are too thick or that contain visible residue may be rejected by consumers, particularly in fresh produce markets where visual appearance is a primary purchasing criterion. Essential oils incorporated as antimicrobials must be used at concentrations that provide effective inhibition without imparting detectable off-flavours or odours to the coated produce (Nain et al., 2021).

### **8.3 In Vivo Bioavailability Validation**

The majority of published evidence for the nutritional preservation efficacy of edible coatings and nanoencapsulation relies on *in vitro* analytical measurements of retained nutrient content and antioxidant capacity during storage, supplemented by *in vitro* simulated gastrointestinal digestion assays. While these data are scientifically informative, they do not directly establish the physiologically relevant endpoint of improved nutrient status in human consumers. The transition from *in vitro* retention data to *in vivo* nutritional benefit requires consideration of the food matrix effects on digestion, the gastrointestinal stability of the coating matrix itself, the kinetics of nanoparticle dissolution and drug release in the complex gut environment, and the influence of individual variation in digestive physiology. Human intervention studies demonstrating improved plasma vitamin concentrations or nutritional biomarker responses to consumption of produce treated with these technologies are critical for substantiating their public health value and are currently lacking in the published literature (Sultana et al., 2022; Patel, 2017).

### **8.4 Environmental and Safety Considerations**

The environmental fate of edible coating residues in wastewater from produce washing operations and of nanoparticles released from coating matrices into the environment represents an underexamined risk. Chitosan, alginate, and other biopolymer coatings are

biodegradable and exhibit low ecotoxicological concern, but their impact on soil microbial communities and aquatic ecosystems when discharged at scale from commercial packhouses requires further assessment. For metallic nanoparticles, including nano-TiO<sub>2</sub> and nano-silver used as antimicrobial additives, the ecotoxicological evidence is more concerning. While these materials may be applied at low concentrations in coating formulations, their persistence in aquatic environments and potential effects on non-target organisms warrant precautionary assessment before large-scale deployment (Patel, 2017).

## 9. Future Directions

Several research frontiers are likely to define the next decade of development in edible coatings and nanoencapsulation for postharvest nutritional preservation. The development of active and intelligent packaging systems that respond to produce ripening signals, releasing antioxidants or antimicrobials on demand in response to changes in ethylene concentration, humidity, or temperature, represents a particularly promising direction. The incorporation of natural anthocyanin-based pH-sensitive indicators into coating matrices offers the prospect of real-time non-destructive freshness monitoring visible to consumers at the point of purchase (Chen et al., 2022).

The precision nutrition paradigm, in which the nutritional composition of food is tailored to the specific requirements of defined consumer populations, opens new applications for nanoencapsulation technology in fortifying commonly consumed produce items with nutrients deficient in specific demographic groups. The encapsulation of iron, zinc, folate, or vitamin B12 within fruit and vegetable coatings would enable delivery of these critical micronutrients through familiar food vehicles without requiring dietary behaviour change, a significant potential public health tool in contexts of endemic micronutrient deficiency.

Artificial intelligence and machine learning approaches to formulation optimisation will accelerate the identification of optimal coating and encapsulation parameters for specific produce-nutrient combinations, reducing the iterative experimental burden currently associated with new material development. High-throughput screening of biopolymer wall materials using computational prediction of molecular barrier properties represents a nascent but promising complementary approach. In the African context, participatory research designs that engage smallholder farmers, packhouse operators, and consumers in the co-development of context-appropriate coating and encapsulation technologies will be essential for ensuring that scientific advances translate into practical adoption (Krishnan & Subramanian, 2025; Martins et al., 2024).

## 10. Conclusion

Edible coatings and nanoencapsulation represent scientifically validated, technologically feasible, and commercially scalable strategies for addressing the biochemically complex problem of postharvest nutrient loss. By targeting the multiple oxidative, enzymatic, microbial, and physical mechanisms of nutritional deterioration through complementary barrier, antioxidant delivery, and bioavailability-enhancing mechanisms, these technologies offer a more comprehensive nutritional preservation solution than any single conventional postharvest intervention. The accumulated evidence from recent peer-reviewed studies confirms consistent improvements of 25 to 60% in the retention of ascorbic acid, carotenoids, and polyphenols across diverse horticultural produce types treated with well-formulated coating and encapsulation systems, with integrated nanoparticle-coating approaches achieving the greatest efficacy.

The demonstrated nutritional significance of underutilised African crops such as *Cyperus esculentus* and *Hibiscus sabdariffa*, documented by Bamishaiye and Bamishaiye (2011) and

Bamishaiye et al. (2011) respectively, reinforces the urgency of developing and deploying appropriate postharvest preservation technologies in contexts where micronutrient deficiency and postharvest loss converge as compounding threats to food and nutrition security. The biochemical vulnerability of these crops to thermal processing, oxidative conditions, and storage-related degradation points directly to the types of interventions that edible coatings and nanoencapsulation are best equipped to provide.

Progress in this field depends on resolving the outstanding challenges of scalable and cost-effective production, regulatory harmonisation for nanomaterials across African and international markets, in vivo validation of nutritional efficacy in human populations, and the development of consumer communication strategies that promote acceptance of novel preservation technologies. Interdisciplinary collaboration among nutritional biochemists, food materials scientists, regulatory specialists, economists, and farming communities will be essential for translating laboratory-scale scientific advances into the smallholder packhouse and the consumer marketplace. With appropriate investment and policy support, edible coatings and nanoencapsulation hold the potential to make a meaningful, measurable contribution to reducing postharvest nutritional losses and improving dietary quality from farm to fork.

### **Declaration of Competing Interest**

The author declares no conflict of interest in connection with the preparation or publication of this work.

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# Application of Artificial Intelligence in Smart Industrial Communication Networks

Engr. Ubani Ajuzieogu Christian PhD<sup>1</sup>, Dr. Joseph Etim Offiong<sup>2</sup>, & Ifelunwa Ada Ikuni<sup>3</sup>

<sup>1</sup>Mechanical Engineering Department, Abia State Polytechnic, Aba, Nigeria

[ajuzieogu.ubani@abiastatepolytechnic.edu.ng](mailto:ajuzieogu.ubani@abiastatepolytechnic.edu.ng)

<sup>2</sup>Electrical and Electronics Engineering Technology Department, Federal Polytechnic Ugep Cross River State Nigeria.

<sup>3</sup>Oracle Corporation Ltd. [joeparry4u@yahoo.com](mailto:joeparry4u@yahoo.com)

## ABSTRACT

*The growing complexity of modern industrial systems has increased the demand for intelligent communication infrastructures capable of supporting automated operations, real-time monitoring and efficient data exchange. Smart industrial communication networks play a critical role in enabling connectivity among machines, sensors and control systems within Industry 4.0 environments. However, challenges such as network congestion, cybersecurity threats, system downtime and inefficient data management continue to affect the performance and reliability of these networks. This study examined the application of artificial intelligence in smart industrial communication networks with emphasis on network efficiency, security and anomaly detection, as well as network reliability and performance. The study adopted a descriptive survey research design. The population consisted of technical and administrative personnel working in communication network, cybersecurity and information technology departments within selected service organisations in Nigeria. A sample size of 269 respondents was determined using Taro Yamane's sampling formula and selected through a stratified sampling technique. Data were collected electronically using a structured questionnaire titled Artificial Intelligence and Industrial Communication Networks Questionnaire (AIICNQ). The instrument was validated by experts and reliability was established using Cronbach's Alpha with a coefficient value of 0.86. Data obtained were analysed using descriptive statistics and multiple linear regression analysis. The findings revealed that artificial intelligence significantly improves the efficiency of smart industrial communication networks through intelligent routing, bandwidth optimisation and predictive maintenance mechanisms.*

KEYWORDS: Artificial Intelligence, Smart Industrial Communication Networks, Industrial Internet of Things, Network Security, Network Efficiency.

## INTRODUCTION

Industrial communication networks constitute the technological backbone of modern manufacturing systems, enabling seamless information exchange among machines, sensors, controllers and enterprise platforms within highly automated production environments. The emergence of smart factories and Industry 4.0 has intensified the demand for communication infrastructures that are intelligent, adaptive and capable of handling large volumes of heterogeneous data in real time. According to Wollschlaeger, Sauter and Jasperneite (2017), industrial communication has evolved from isolated fieldbus architectures to interconnected cyber-physical systems that integrate operational technology with information technology. This transformation has increased system complexity and created new challenges in network management, security, reliability and latency control. Within this context, Artificial Intelligence

(AI) has gained prominence as a technological mechanism capable of improving decision-making, predictive capability and automation within industrial communication frameworks. Recent developments in machine learning, deep learning and intelligent data analytics have strengthened the potential of AI to optimise industrial network operations. As noted by Zhang, Chen and Li (2022), AI-driven systems can analyse network traffic patterns, detect anomalies and dynamically allocate resources to ensure efficient data transmission across smart industrial infrastructures. The integration of AI into communication networks also enables predictive maintenance of network components, intelligent fault diagnosis and adaptive routing strategies that enhance operational resilience. Furthermore, the convergence of AI with Industrial Internet of Things (IIoT) technologies allows interconnected devices to communicate autonomously while learning from data generated within manufacturing environments. Empirical studies have examined the role of AI techniques in addressing communication challenges within smart industrial environments. Lu and Cecil (2016) investigated the application of machine learning algorithms in industrial cyber-physical systems and reported that intelligent monitoring systems significantly improve network efficiency and reduce downtime in manufacturing operations. Their study demonstrated that AI-based analytics can identify hidden patterns in network behaviour and support proactive management strategies.

Similarly, Shi, Cao, Zhang, Li and Xu (2016) analysed the architecture of the Industrial Internet of Things and highlighted that intelligent communication mechanisms are critical for enabling distributed devices to interact effectively within complex industrial ecosystems. Further research has focused on the integration of AI for network optimisation and intelligent resource management in industrial systems. Park, Samarakoon, Bennis and Debbah (2020) explored the use of deep learning techniques for managing communication resources in industrial wireless networks. Their findings indicated that AI-based resource allocation models outperform traditional optimisation approaches by dynamically adapting to changing network conditions. The study revealed that machine learning models can learn traffic behaviour and adjust communication parameters automatically, thereby improving throughput and reducing network congestion in smart manufacturing environments. Security within industrial communication networks has also attracted scholarly attention due to the increasing exposure of industrial systems to cyber threats. Ferrag, Shu, Yang, Derhab and Maglaras (2020) examined the application of deep learning techniques for intrusion detection in industrial networks. Their research showed that AI-driven security frameworks can effectively detect abnormal network activities and identify sophisticated cyber-attacks that conventional rule-based systems may fail to recognise. Research has explored the application of reinforcement learning and predictive analytics in enhancing communication efficiency across industrial networks. Zhang, Patras and Haddadi (2019) conducted experimental analysis on AI-enabled network optimisation and found that reinforcement learning algorithms can dynamically adjust routing strategies to improve data delivery performance in complex communication environments. Recent studies further emphasise the role of AI in enabling self-organising and autonomous communication networks in smart factories. Bello, Zeadally, Badra and Farah (2021) analysed AI-driven network management frameworks for Industry 4.0 environments and reported that intelligent network orchestration enhances system scalability and interoperability among heterogeneous industrial devices.

### **Statement of Problem**

The integration of heterogeneous devices, sensors and cyber-physical systems generates large volumes of real-time data that traditional network management approaches struggle to process efficiently. According to Wollschlaeger, Sauter and Jasperneite (2017), conventional industrial communication frameworks were originally designed for relatively static environments and therefore lack the adaptability required for highly dynamic smart industrial

systems. Industrial communication networks have become fundamental to smart manufacturing and Industry 4.0 environments, yet their increasing complexity introduces persistent operational and security challenges. These challenges are further intensified by the growing reliance on autonomous machine-to-machine communication within distributed industrial infrastructures. Research by Park, Samarakoon, Bennis and Debbah (2020) indicates that traditional rule-based network control mechanisms are often inadequate for managing complex communication environments characterised by unpredictable traffic patterns. In addition, industrial communication networks remain exposed to sophisticated security threats due to limited intelligent monitoring and weak anomaly detection mechanisms. Ferrag et al. (2020) observed that many industrial systems still rely on reactive security frameworks that are incapable of detecting emerging cyber threats in real time, thereby placing critical infrastructure at significant operational risk. Despite increasing scholarly attention to artificial intelligence applications in industrial systems, existing studies have largely focused on general network optimisation or IoT security without providing comprehensive frameworks specifically tailored for intelligent communication management within smart industrial environments. Furthermore, limited empirical attention has been given to the integration of AI techniques for adaptive network control, predictive fault detection and intelligent communication resource management in industrial networks.

### **Research Objectives**

The study primarily examined the application of artificial intelligence in smart industrial communication networks. Specifically, the study sought to:

- examine the role of artificial intelligence in enhancing the efficiency of smart industrial communication networks.
- evaluate the effectiveness of artificial intelligence in improving security and anomaly detection in smart industrial communication networks.
- determine the influence of artificial intelligence on network reliability and performance in smart industrial communication systems.

### **Research Questions**

- What is the role of artificial intelligence in enhancing the efficiency of smart industrial communication networks?
- What is the effectiveness of artificial intelligence in improving security and anomaly detection in smart industrial communication networks?
- What is the influence of artificial intelligence on network reliability and performance in smart industrial communication systems?

### **Conceptual Framework**

#### **Concept of Artificial Intelligence**

Artificial Intelligence (AI) refers to the capability of computer systems to perform tasks that normally require human intelligence, such as learning, reasoning, decision-making and pattern recognition. Russell and Norvig (2021) defined artificial intelligence as the design and development of intelligent agents capable of perceiving their environment and taking actions that maximise the chances of achieving specified goals. The historical development of AI dates back to the mid-twentieth century when early computational models attempted to simulate human reasoning processes. The core components of AI include machine learning, deep

learning, neural networks and expert systems, which enable intelligent data processing and automated decision-making. According to Goodfellow, Bengio and Courville (2016), deep learning architectures have transformed the development of AI systems by allowing computers to automatically extract complex patterns from large datasets. These technologies operate through sophisticated algorithms and intelligent data analytics that enable predictive modelling, pattern detection and adaptive learning processes. AI algorithms are increasingly integrated with big data technologies to facilitate intelligent analysis of complex datasets across various sectors. The increasing integration of AI into digital systems has also accelerated technological transformation associated with Industry 4.0. Schwab (2017) observed that artificial intelligence plays a central role in enabling smart automation, intelligent robotics and data-driven industrial decision systems. In industrial environments, AI is widely applied in predictive maintenance, automated quality control, intelligent manufacturing and supply chain optimisation. Empirical studies have also shown that AI technologies enhance operational productivity, reduce system downtime and improve decision accuracy in automated systems (Jordan & Mitchell, 2015).

### **Concept of Smart Industrial Communication Networks**

Smart industrial communication networks represent advanced communication infrastructures that facilitate seamless interaction among machines, sensors, controllers and digital platforms within modern industrial environments. These networks enable the transmission of large volumes of real-time data across interconnected industrial systems, supporting automation and intelligent decision-making processes. Sauter (2017) described industrial communication networks as the technological framework that connects distributed industrial devices and enables reliable information exchange within manufacturing and control systems. The evolution from conventional industrial communication architectures to smart networks has been largely influenced by technological advancements in networking protocols, cloud computing and the Industrial Internet of Things (IIoT). According to Xu, He and Li (2014), the Industrial Internet of Things integrates sensors, embedded systems and communication technologies to create interconnected industrial infrastructures capable of exchanging information continuously. Through IIoT technologies, machines and industrial devices are able to communicate autonomously, enabling data-driven production environments characterised by intelligent monitoring and adaptive control. Smart industrial communication infrastructures consist of multiple components including sensors, actuators, programmable logic controllers, communication gateways and cloud-based data platforms. These elements interact within cyber-physical systems that integrate computational processes with physical industrial operations. Lee, Bagheri and Kao (2015) emphasised that cyber-physical integration enables industrial systems to analyse operational data and respond dynamically to environmental changes. Real-time data exchange within these networks is essential for ensuring operational efficiency, process synchronisation and system responsiveness within smart factories. Despite their technological advantages, smart industrial communication networks face several operational challenges including network congestion, latency issues, cybersecurity vulnerabilities and interoperability limitations among heterogeneous devices.

### **Artificial Intelligence and Industrial Network Efficiency**

Network efficiency within industrial communication systems refers to the ability of communication infrastructures to transmit data reliably, rapidly and with minimal resource consumption while maintaining stable operational performance. Efficient communication networks are essential for supporting real-time monitoring, automation and coordination among industrial devices within smart manufacturing environments. The integration of artificial intelligence technologies has emerged as a strategic approach for improving the efficiency of industrial communication systems. Zhang, Patras and Haddadi (2019) reported

that machine learning algorithms can analyse complex network traffic patterns and optimise data routing processes within modern communication infrastructures. Artificial intelligence techniques enable intelligent optimisation of bandwidth utilisation and communication resource allocation within industrial networks. Machine learning models are capable of analysing historical network data to identify traffic patterns, detect anomalies and forecast communication demands. Mao, You, Zhang, Huang and Letaief (2018) observed that AI-driven network optimisation significantly improves communication efficiency by enabling dynamic adjustment of network parameters based on real-time operational conditions. These capabilities enhance the responsiveness of industrial communication systems and reduce the occurrence of network congestion. AI-based predictive maintenance mechanisms also contribute to improved network efficiency by identifying potential failures in communication equipment before they occur. Through continuous monitoring and intelligent diagnostics, AI systems are able to detect irregular network behaviour and initiate corrective measures automatically. Research has further demonstrated that intelligent routing algorithms enhance communication performance by ensuring efficient data transmission across distributed industrial infrastructures (Minerva, Biru & Rotondi, 2015).

### **Artificial Intelligence for Security and Anomaly Detection in Industrial Networks**

Artificial intelligence for security and anomaly detection refers to the use of intelligent computational techniques to identify abnormal behaviour, cyber intrusions and system vulnerabilities within industrial communication networks. Industrial communication environments are increasingly exposed to cyber threats such as distributed denial-of-service attacks, malware infiltration and unauthorised access due to the extensive interconnection of devices and control systems. Conti, Dehghantanha, Franke and Watson (2018) noted that smart industrial networks possess inherent vulnerabilities because heterogeneous devices often operate with limited security protocols. AI-based intrusion detection systems have therefore been introduced to strengthen security monitoring and threat identification in industrial infrastructures. Machine learning algorithms analyse network traffic patterns to detect deviations from normal operational behaviour. Furthermore, deep learning techniques enable advanced pattern recognition capable of identifying sophisticated cyber threats in large-scale communication systems.

### **Artificial Intelligence and Network Reliability**

Artificial intelligence contributes significantly to network reliability within industrial communication systems by enabling intelligent monitoring, predictive diagnostics and automated fault detection. Network reliability refers to the ability of communication infrastructures to maintain consistent performance and availability during operational processes. According to Nguyen and Reddi (2021), AI-driven predictive analytics enables early identification of potential failures within network components through continuous analysis of operational data. Intelligent diagnostics supported by machine learning algorithms enhance system monitoring and enable proactive maintenance strategies. Additionally,

### **Artificial Intelligence and Network Performance in Smart Industrial Systems**

Artificial intelligence plays an increasingly significant role in improving network performance within smart industrial communication systems. Network performance refers to the effectiveness with which communication infrastructures deliver data across interconnected industrial devices while maintaining acceptable levels of latency, throughput and availability. High-performance communication networks are essential for supporting real-time monitoring, automation and synchronisation within modern smart factories. Sun, Peng, Zhou, Huang and Wang (2020) reported that artificial intelligence techniques enable dynamic optimisation of communication processes through intelligent traffic analysis and adaptive resource

allocation. AI-driven optimisation mechanisms improve network performance by analysing operational data and adjusting communication parameters in response to changing network conditions. Intelligent communication protocols supported by machine learning algorithms enhance data routing efficiency and minimise transmission delays across distributed industrial infrastructures. Taleb, Samdanis, Mada, Flinck, Dutta and Sabella (2017) observed that AI-enabled adaptive network management significantly improves system responsiveness by enabling communication systems to self-adjust according to workload fluctuations.

## **Theoretical Framework**

### **Diffusion of Innovation Theory**

Diffusion of Innovation Theory explains how new technologies, ideas and innovations spread across organisations and social systems over time. Rogers (2003) described diffusion as the process through which an innovation is communicated through particular channels among members of a social system. The theory emphasises five key attributes that influence the adoption of innovations: relative advantage, compatibility, complexity, trialability and observability. These attributes determine the extent to which individuals or organisations adopt new technological solutions. In technologically driven environments, innovations are more likely to be adopted when they demonstrate clear operational benefits and compatibility with existing systems. Empirical studies have shown that diffusion theory has been widely applied in analysing the adoption of digital technologies, particularly in organisational and industrial contexts. Venkatesh, Thong and Xu (2016) noted that organisations adopt emerging technologies when perceived performance benefits outweigh the risks and complexities associated with implementation. In industrial environments, the diffusion of advanced technologies such as artificial intelligence depends on organisational readiness, infrastructure capability and perceived efficiency improvements. The relevance of this theory to the present study lies in its ability to explain the adoption and integration of artificial intelligence within smart industrial communication networks.

### **Systems Theory**

Systems Theory emphasises that organisations and technological infrastructures operate as interconnected systems composed of multiple interacting components that function collectively to achieve specific objectives. Bertalanffy (1968) conceptualised systems theory as an analytical framework that explains how complex structures are formed through the interaction of different subsystems within a unified whole. In technological environments, systems theory highlights the importance of coordination among hardware, software, communication networks and data-processing mechanisms. According to Meadows (2008), effective system performance depends on the dynamic relationships among system components rather than isolated elements. Industrial communication networks operate as complex systems where sensors, controllers, communication protocols and computing platforms interact continuously to enable automated production processes.

### **Research Methodology**

The study adopted a descriptive survey research design to systematically obtain data from selected service organisations on artificial intelligence and industrial communication networks. The study was conducted across selected technology-oriented service organisations located in major industrial and commercial cities in Nigeria where digital communication infrastructures are widely utilised. These organisations included MTN Nigeria Communications Plc located in Lagos State, Globacom Limited situated in Victoria Island, Lagos State, and MainOne Cable Company headquartered in Lagos but with operational centres in Port Harcourt, Rivers State and Abuja, Federal Capital Territory. These locations were selected

because they represent major hubs of industrial digital infrastructure and advanced communication services in Nigeria. The selected organisations provide network management, data communication services and digital infrastructure support that integrate advanced technologies such as artificial intelligence in their operational systems. The population of the study comprised technical and administrative personnel working in departments directly related to communication networks, cybersecurity, information technology and data analytics within the selected organisations. Personnel records obtained from the human resource departments of the selected service organisations indicated that the combined workforce of relevant departments consisted of 820 employees. These employees were distributed across network operations, cybersecurity management, information technology services, data analytics units and research and development departments within the selected organisations.

A multi-stage sampling technique was adopted to select respondents for the study. In the first stage, three major service organisations were purposively selected based on their involvement in digital communication infrastructure management. In the second stage, departments associated with communication networks, cybersecurity, data analytics and information technology were identified within each organisation. In the third stage, proportionate stratified sampling was applied to ensure equal representation of respondents across the selected departments. The sample size was determined using Taro Yamane's (1967) sampling formula:  $N / (1 + N(e)^2)$ , where  $n$  represents the sample size,  $N$  represents the population size and  $e$  represents the level of precision (0.05). Based on this calculation, a sample size of 269 respondents was obtained and proportionately distributed across the selected organisations. Data for the study were collected using a structured electronic questionnaire titled Artificial Intelligence and Industrial Communication Networks Questionnaire (AIICNQ). The questionnaire was designed to obtain information relating to artificial intelligence applications, network efficiency, cybersecurity monitoring and communication system performance within industrial environments. The instrument consisted of two sections. Section A obtained demographic information of respondents, while Section B contained structured statements developed in line with the study objectives and measured using a five-point Likert scale ranging from strongly agree to strongly disagree.

Content and face validity were established through expert review by three specialists in information technology and research methodology who assessed clarity and relevance. Reliability was tested using Cronbach's Alpha through a pilot study, producing a reliability coefficient of 0.86, indicating high internal consistency. The questionnaire was administered electronically using an online survey platform. The link to the questionnaire was distributed to respondents through official organisational email systems and professional communication channels with the support of departmental coordinators within the selected organisations. Respondents completed the questionnaire remotely through digital devices, ensuring wider accessibility and efficient data collection across different organisational locations. A total of 269 questionnaires were distributed electronically, out of which 254 questionnaires were successfully completed and returned, representing a high response rate suitable for data analysis in the study. Data collected were analysed using descriptive statistics and inferential statistical techniques through Statistical Package for Social Sciences (SPSS) software.

## **Data Analysis**

### **Research Question 1:**

What is the role of artificial intelligence in enhancing the efficiency of smart industrial communication networks? In order to answer the research question, descriptive analysis was performed on the data collected (Table 1).

**Table 1: Descriptive Statistics on the Role of Artificial Intelligence in Enhancing Network Efficiency**

S/N	Item Statements	SA (5)	A (4)	N (3)	D (2)	SD (1)	Mean	SD
1	AI improves data transmission efficiency in industrial networks	92 (36.22%)	84 (33.07%)	38 (14.96%)	25 (9.84%)	15 (5.91%)	3.84	1.12
2	AI optimises bandwidth usage in industrial communication systems	86 (33.86%)	88 (34.65%)	41 (16.14%)	23 (9.06%)	16 (6.30%)	3.81	1.15
3	AI supports intelligent routing for faster data delivery	95 (37.40%)	80 (31.50%)	39 (15.35%)	24 (9.45%)	16 (6.30%)	3.85	1.14
4	AI reduces network congestion in industrial environments	90 (35.43%)	83 (32.68%)	42 (16.54%)	26 (10.24%)	13 (5.12%)	3.83	1.11
5	AI enhances real-time communication efficiency in smart factories	94 (37.01%)	85 (33.46%)	36 (14.17%)	24 (9.45%)	15 (5.91%)	3.87	1.10
	<b>Aggregate</b>	<b>457</b>	<b>420</b>	<b>196</b>	<b>122</b>	<b>75</b>	<b>3.84</b>	<b>1.12</b>
	<b>Proportional Ratio</b>	<b>35.98%</b>	<b>33.07%</b>	<b>15.43%</b>	<b>9.61%</b>	<b>5.91%</b>		

Table 1 indicates respondents' views on the role of artificial intelligence in improving efficiency of smart industrial communication networks. Item 1 recorded 92 (36.22%) strongly agreeing and 84 (33.07%) agreeing with a mean of 3.84. Item 2 showed 86 (33.86%) strongly agreeing and 88 (34.65%) agreeing with mean 3.81. Item 3 revealed 95 (37.40%) strongly agreeing and 80 (31.50%) agreeing with mean 3.85. Item 4 recorded 90 (35.43%) strongly agreeing and 83 (32.68%) agreeing with mean 3.83. Item 5 showed 94 (37.01%) strongly agreeing and 85 (33.46%) agreeing with mean 3.87. The aggregate mean of 3.84 indicates strong agreement among respondents.

**Research Question 2:**

What is the effectiveness of artificial intelligence in improving security and anomaly detection in smart industrial communication networks? In order to answer the research question, descriptive analysis was performed on the data collected (Table 2).

**Table 2: Descriptive Statistics on AI for Security and Anomaly Detection**

S/N	Item Statements	SA (5)	A (4)	N (3)	D (2)	SD (1)	Mean	SD
1	AI detects cyber threats in industrial communication systems	98 (38.58%)	79 (31.10%)	37 (14.57%)	24 (9.45%)	16 (6.30%)	3.87	1.13
2	AI improves intrusion detection in industrial networks	91 (35.83%)	84 (33.07%)	40 (15.75%)	25 (9.84%)	14 (5.51%)	3.85	1.12
3	Machine learning identifies abnormal network behaviour	96 (37.80%)	82 (32.28%)	39 (15.35%)	23 (9.06%)	14 (5.51%)	3.88	1.10
4	AI predicts potential security attacks in industrial systems	88 (34.65%)	87 (34.25%)	42 (16.54%)	23 (9.06%)	14 (5.51%)	3.84	1.13
5	AI strengthens monitoring of industrial communication networks	94 (37.01%)	83 (32.68%)	41 (16.14%)	22 (8.66%)	14 (5.51%)	3.87	1.09

S/N	Item Statements	SA (5)	A (4)	N (3)	D (2)	SD (1)	Mean	SD
	<b>Aggregate</b>	<b>467</b>	<b>415</b>	<b>199</b>	<b>117</b>	<b>72</b>	<b>3.86</b>	<b>1.11</b>
	<b>Proportional Ratio</b>	<b>36.77%</b>	<b>32.68%</b>	<b>15.67%</b>	<b>9.21%</b>	<b>5.67%</b>		

Table 2 shows respondents' perception of artificial intelligence in improving security and anomaly detection in industrial communication networks. Item 1 recorded 98 (38.58%) strongly agreeing and 79 (31.10%) agreeing with mean 3.87. Item 2 showed 91 (35.83%) strongly agreeing and 84 (33.07%) agreeing with mean 3.85. Item 3 revealed 96 (37.80%) strongly agreeing and 82 (32.28%) agreeing with mean 3.88. Item 4 indicated 88 (34.65%) strongly agreeing and 87 (34.25%) agreeing with mean 3.84. Item 5 recorded 94 (37.01%) strongly agreeing and 83 (32.68%) agreeing with mean 3.87. The aggregate mean of 3.86 indicates that respondents widely recognised AI as effective for industrial network security monitoring.

### Research Question 3:

What is the influence of artificial intelligence on network reliability and performance in smart industrial communication systems? In order to answer the research question, descriptive analysis was performed on the data collected (Table 3).

**Table 3: Descriptive Statistics on AI Influence on Network Reliability and Performance**

S/N	Item Statements	SA (5)	A (4)	N (3)	D (2)	SD (1)	Mean	SD
1	AI improves reliability of industrial communication networks	89 (35.04%)	87 (34.25%)	41 (16.14%)	23 (9.06%)	14 (5.51%)	3.84	1.11
2	AI reduces communication system downtime	92 (36.22%)	82 (32.28%)	40 (15.75%)	24 (9.45%)	16 (6.30%)	3.83	1.14
3	AI supports predictive maintenance of network systems	97 (38.19%)	80 (31.50%)	39 (15.35%)	23 (9.06%)	15 (5.91%)	3.87	1.12
4	AI enhances network stability in smart factories	90 (35.43%)	84 (33.07%)	42 (16.54%)	24 (9.45%)	14 (5.51%)	3.85	1.10
5	AI improves overall performance of industrial networks	95 (37.40%)	83 (32.68%)	38 (14.96%)	24 (9.45%)	14 (5.51%)	3.88	1.09
	<b>Aggregate</b>	<b>463</b>	<b>416</b>	<b>200</b>	<b>118</b>	<b>73</b>	<b>3.85</b>	<b>1.11</b>
	<b>Proportional Ratio</b>	<b>36.46%</b>	<b>32.76%</b>	<b>15.75%</b>	<b>9.29%</b>	<b>5.74%</b>		

Table 3 presents responses on the influence of artificial intelligence on network reliability and performance in smart industrial communication systems. Item 1 recorded 89 (35.04%) strongly agreeing and 87 (34.25%) agreeing with mean 3.84. Item 2 showed 92 (36.22%) strongly agreeing and 82 (32.28%) agreeing with mean 3.83. Item 3 indicated 97 (38.19%) strongly agreeing and 80 (31.50%) agreeing with mean 3.87. Item 4 recorded 90 (35.43%) strongly agreeing and 84 (33.07%) agreeing with mean 3.85. Item 5 revealed 95 (37.40%) strongly agreeing and 83 (32.68%) agreeing with mean 3.88. The aggregate mean value of 3.85 shows that respondents largely acknowledged AI's influence on network reliability and system performance.

## Conclusion

The study examined the application of artificial intelligence in smart industrial communication networks with particular focus on network efficiency, security and anomaly detection, as well as network reliability and performance within industrial communication systems. Findings from the descriptive and inferential analyses revealed that artificial intelligence plays a significant role in enhancing communication efficiency through intelligent data routing, bandwidth optimisation and predictive maintenance within industrial networks. Furthermore, the findings indicated that artificial intelligence significantly influences the reliability and performance of smart industrial communication networks by enabling intelligent diagnostics, automated system monitoring and adaptive communication management. These capabilities support continuous system operation and minimise disruptions within highly interconnected industrial environments. The regression analyses further confirmed that the variables examined exerted significant effects on the dependent constructs, indicating that the integration of artificial intelligence technologies contributes meaningfully to improving operational outcomes within industrial communication infrastructures. Overall, the study demonstrated that the increasing complexity of modern industrial communication environments requires intelligent technological solutions capable of managing large volumes of real-time data while ensuring system stability and security. The integration of artificial intelligence within smart industrial communication networks therefore represents a critical technological development that strengthens network performance, enhances cybersecurity mechanisms and improves the operational efficiency of industrial communication systems within the evolving digital industrial landscape.

## Recommendations

- Industrial organisations should strengthen the integration of artificial intelligence technologies within their communication infrastructures in order to improve data transmission efficiency, intelligent routing mechanisms and adaptive network management in smart industrial environments.
- Service organisations and industrial network operators should adopt AI-driven cybersecurity frameworks capable of detecting network intrusions, identifying abnormal communication patterns and predicting potential cyber threats in real time within smart industrial communication systems.
- Organisations should invest in advanced AI-based predictive maintenance systems to continuously monitor network components, detect potential communication faults early and reduce system downtime within industrial communication infrastructures.
- Management of service organisations should promote continuous training and capacity development for technical personnel to enhance professional competence in artificial intelligence, machine learning and intelligent network management technologies used in industrial communication systems.
- Government and regulatory institutions should encourage research and technological innovation in artificial intelligence applications through supportive policies and digital infrastructure development to strengthen the deployment of intelligent communication networks across industrial sectors.

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