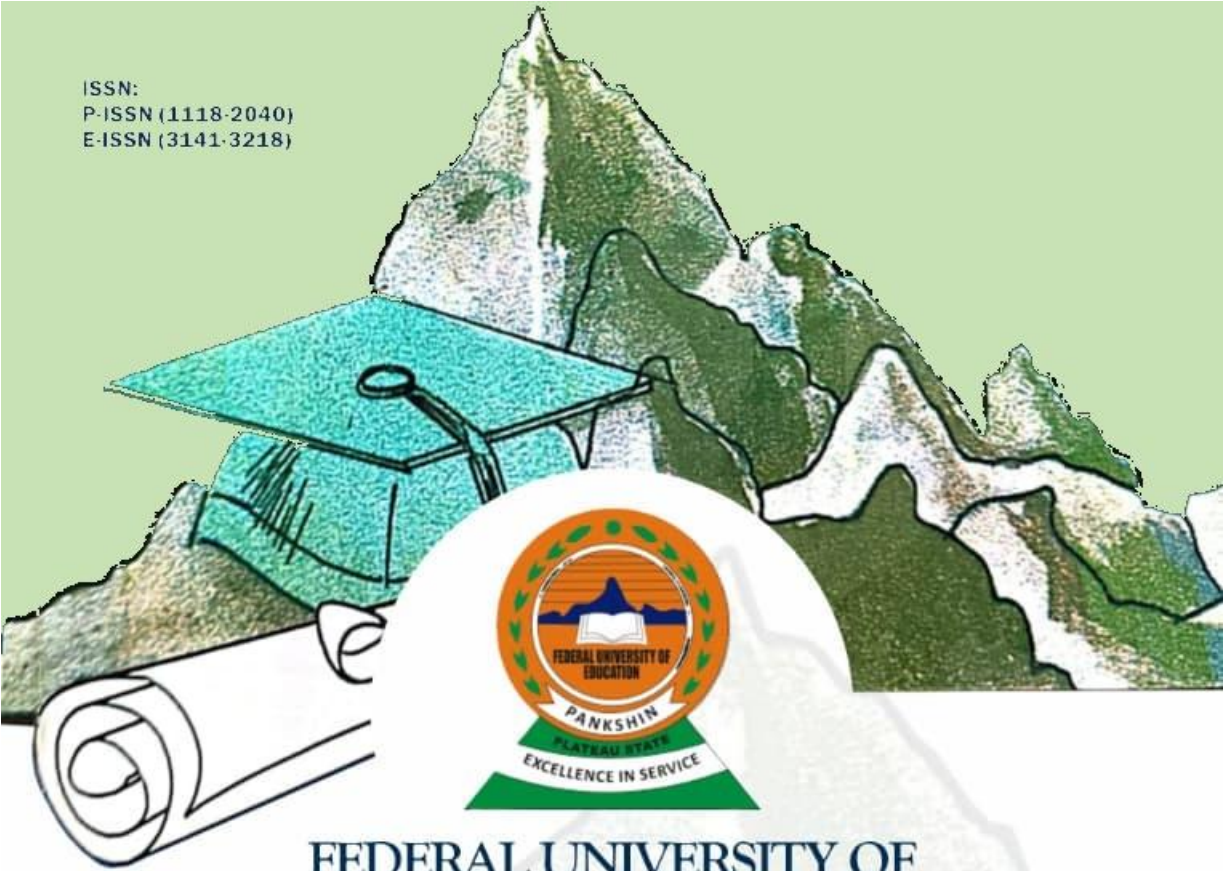


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Authors/Contributors should adhere strictly to the underlisted guidelines on presentation. Articles, which fail to make these requirements, may be rejected.

- All articles must be original and written in English language.
- Articles or papers should not exceed 15 pages including tables and references. They should be typed, double spaced, 12 font size, on one side of A4 paper and preferably on Times New Romans.
- The title should contain name(s), status, address(es), email address(es) and phone numbers of the authors to enhance communication.
- The title should be concise, self-explanatory and not more than 20 words.
- There should be an abstract of not more than 200 words.
- All tables, graphs and diagrams should be in appropriate place in the paper and not on separate sheets. They should be correctly and suitably titled. Tables should be reduced to the barest minimum.
- The current APA style of citation and referencing should be strictly adhered to.
- Key words of not more than five should be provided below the abstract.
- Simultaneous submission of articles to PAJE and other Journal should be avoided.
- All articles are subject to peer review. Accepted articles for publication may be edited to improve their overall quality.

EDITORIAL FOREWORD

It is with immense pleasure and a profound sense of academic responsibility that I present Volume 2, Number 2 of the Pancen Journal of Education (PAJE) to our esteemed readers. This issue comes at a particularly significant moment in the history of education, when rapid technological advancement is fundamentally reshaping the nature, processes and purposes of teaching and learning.

The contemporary educational landscape is increasingly characterised by the integration of Information and Communication Technologies (ICT), digital learning platforms, Artificial Intelligence (AI), virtual reality, mobile technologies and other emerging digital innovations. These developments present unprecedented opportunities for enhancing educational access, quality, efficiency and inclusivity, while simultaneously introducing new pedagogical, ethical, professional and institutional challenges. It is against this dynamic background that the present issue is organised.

The scholarly contributions assembled in this volume collectively interrogate different dimensions of technology-mediated education, educational innovation, learner development, teacher competence and institutional quality assurance. Although diverse in subject matter and disciplinary orientation, the papers converge on a common concern: how education systems can respond meaningfully and responsibly to the demands of a rapidly changing technological and knowledge society.

The opening article, “Digital Transformation in Financial Accounting Education: Challenges of Implementing Computerised Accounting Systems (CAS) in Tertiary Institutions,” by Oke-Potefa Oladele Sewanu and colleagues, draws attention to the transformation of accounting education through computerised accounting systems.

This is followed by “Artificial Intelligence-Driven Educational Transformation: A Review of Emerging Technologies and Their Impact on Teaching and Learning,” authored by Abdullahi Ayegba and others.

The third contribution, “Handheld Mobile Devices, Artificial Intelligence, and Study Habits among Secondary School Biology Students in Abia State, Nigeria,” by Samuel Pius and colleagues, examines the increasingly important intersection of mobile technology, Artificial Intelligence and students’ learning behaviours. Its focus is particularly relevant in an era in which handheld digital devices have become integral to young people’s everyday academic and social experiences.

In “Effects of AI-Driven Real-Time Captioning as an Orthographic Scaffold for Literacy Acquisition among Deaf Learners in Plateau State, Nigeria,” Milaham S. Rahila and Tuka S. Nendelmwa bring an important dimension of inclusion to the technology discourse.

The fifth article, “Digital Platform Use, Gender, and Age Differences in Cyberbullying Experiences among Adolescents in Ondo State, Nigeria,” by Makinwa Idowu Victoria, reminds us that digital transformation is not without social consequences by examining cyberbullying experiences in relation to digital platform use.

The question of Artificial Intelligence-supported learning is further explored in the sixth paper, “Self-Reported Utilisation Patterns of Artificial Intelligence-Generated Feedback among Undergraduate Science Students in Tertiary Institutions in Kwara State, Nigeria,” by Abdulrahim Basira Jibril and colleagues. The paper focuses on students’ engagement with AI-generated feedback and contributes to

understanding the emerging role of AI in supporting academic learning, particularly within science education.

The seventh article, “ICT Proficiency Needs of Agricultural Education Lecturers for Instructional Purposes in Tertiary Institutions in South Western Nigeria,” by Ajala Oluwole Samuel and his colleague shift attention from learners to educators. Its focus on lecturers’ ICT proficiency needs underscores a fundamental condition for successful digital transformation.

Similarly connecting technology with education and national development is the eighth contribution, “Comparative Effects of Virtual Reality and Video-Based Learning on Immediate Achievement and Concept Retention in Senior Secondary School Physics in Rivers State, Nigeria,” by Nwuche Emmanuella Chizoba. Through its comparative orientation, the paper engages with the pedagogical possibilities of immersive and video-based technologies for improving learners’ understanding and retention of scientific concepts.

The ninth paper, “Secondary School Teachers’ Knowledge and Utilisation of Agro-Digital Technologies for Perceived Agripreneurship Competency Development in Odogbolu Local Government Area, Ogun State, Nigeria,” by Sanni M. A. and colleagues expands the technological discourse into agricultural education and entrepreneurship. Its focus on agro-digital technologies and agripreneurship competency development is especially pertinent to Nigeria’s quest for an innovative, productive and technology-enabled agricultural sector capable of creating sustainable livelihoods for its growing population.

The final contribution, “School Inspectors’ Supervisory Behaviour and Teachers’ Instructional Practices in Public Primary Schools in Osogbo Local Government Area, Osun State, Nigeria,” by Adeleke Florence Oluwaseye and colleagues, complements the technology-oriented contributions by addressing a fundamental dimension of educational quality: effective supervision. The paper emphasises the continuing importance of instructional leadership, supervision and professional practice in achieving desirable educational outcomes.

Considered collectively, the contributions in this issue demonstrate that the transformation of education in the twenty-first century must be understood as a multidimensional process. Digital technologies and Artificial Intelligence undoubtedly offer powerful tools for improving educational practice, but their effectiveness ultimately depends on the quality of human engagement, institutional preparedness, teacher competence, learner disposition, ethical considerations and supportive educational policies.

The significance of these contributions extends beyond Nigeria. Across the world, education systems are confronting similar questions concerning the appropriate integration of Artificial Intelligence, digital equity, emerging pedagogies, teacher preparedness, learner wellbeing and the future of work. The scholarship contained in this volume therefore participates in a broader international intellectual conversation on how education can harness technological advancement without losing sight of its fundamental human and societal purposes.

I hereby express my profound appreciation to the Tertiary Education Trust Fund (TETFund) for its sponsorship and invaluable support towards the publication of this issue. I also extend our sincere gratitude to the Management of the Federal University of Education, Pankshin, Nigeria, for its continued commitment to academic excellence and for providing an enabling environment for research, scholarship

and knowledge dissemination. Our deepest appreciation goes to the contributors to this volume for their intellectual commitment, diligence and dedication to expanding the frontiers of educational knowledge. Their scholarly efforts constitute an important contribution to the continuing development of education in Nigeria and beyond.

I equally acknowledge the efforts of the Editorial Board, reviewers and all those whose contributions, whether visible or otherwise, have helped bring this issue to fruition. The quality and sustainability of scholarly publishing depend upon such collective commitment to intellectual rigour, academic integrity and the advancement of knowledge.

As we present this issue to the academic community, we do so with the hope that the ideas contained in its pages will stimulate further inquiry, inspire innovation, inform educational policy and practice, and encourage deeper reflection on the future of education in an increasingly digital world.

It is therefore my pleasure to welcome our readers to Volume 2, Number 2 of the Pancen Journal of Education (PAJE). May the scholarship presented in this issue provoke meaningful conversations, generate new research pathways and contribute, in its own modest but significant way, to the advancement of education, national development and global knowledge.

Professor Jere Ndazhaga

Editor-in-Chief

Pancen Journal of Education (PAJE)

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Digital Transformation in Financial Accounting Education: Challenges of Implementing Computerised Accounting Systems (CAS) in Tertiary Institutions

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Abstract

This study examines the institutional, technical, and operational barriers hindering effective implementation of Computerised Accounting Systems (CAS) in tertiary institutions. Adopting a descriptive survey research design, primary data were collected from a purposively selected sample of 123 accounting educators and IT administrators across selected public and private tertiary institutions. The study integrates the Technology Acceptance Model (TAM) and Institutional Theory as its theoretical framework. A structured 22-item, 5-point Likert-scale questionnaire was administered. Multiple linear regression analysis revealed that the model explained 71.4% of the variance in CAS implementation success ($R^2 = 0.714$, Adjusted $R^2 = 0.702$, $F(3,116) = 96.42$, $p < 0.001$). Technical infrastructure quality emerged as the strongest predictor ($\beta = 0.537$, $t = 8.391$, $p < 0.001$), followed by faculty training and operational competency ($\beta = 0.339$, $t = 6.647$, $p < 0.001$), and institutional management support and funding ($\beta = 0.211$, $t = 4.395$, $p = 0.001$). These findings indicate that infrastructure deficiencies, inadequate faculty upskilling, and insufficient management commitment constitute critical bottlenecks to successful digital transformation. Effective CAS implementation requires more than software acquisition; it demands systemic resolution of deep-rooted institutional weaknesses. Recommendations include comprehensive ICT infrastructure overhaul, mandatory continuous faculty development programmes with cyber security components, increased budgetary allocation for digital initiatives, and strategic partnerships with accounting software vendors.

Keywords: Digital transformation, Computerised Accounting Systems (CAS), financial accounting education, Technology Acceptance Model (TAM), Institutional Theory, tertiary institutions

Introduction

The accounting and finance profession has seen a drastic change in the last few decades whereby it has transitioned from traditional bookkeeping practices to modern technological practices incorporating automation, cloud computing, analysis and ERP (Busulwa et al., 2026; Pan and Seow, 2016). The changes have been attributed to technological advancements of Industry 4.0 and the need to cater for an advanced economy where accounting goes beyond compliance and reporting (Tiron-Tudor et al., 2025; Satjawisate et al., 2025).

Tertiary education institutions that provide education and training to the future accountants need to adjust accordingly. While traditional accounting courses focused on theoretical aspects including accounting standards, auditing concepts and management accounting, it has been found out that due to the incorporation of technology, most students are theoretically well prepared, but lack skills on how to use modern accounting software (Vasquez et al., 2026; Tee et al., 2024).

There is no doubt that there is an ever-increasing discrepancy between the educational programme and the requirements of employers. There are more and more companies that require skilled professionals in digital technology, whereas most students lack practical skills related to modern software for accounting and data management, resulting in a slow adaptation period and less productivity (Nie and Mastor, 2024; Manalo et al., 2025).

The use of Computerised Accounting System (QuickBooks, Sage, Xero, or complete ERP systems) was recognised as crucial (Harrast et al., 2014; Busulwa et al., 2026). Using CAS allows hands-on practice by transaction posting, financial statement preparation, and analysis and increases professional competencies (Manalo et al., 2025). Several studies have shown that this leads to better job market outcomes of graduates (Pan and Seow, 2016).

However, the implementation of CAS in higher education involves several difficulties: high costs, low level of preparedness of educators, limitations of the curriculum, constant changes in the software, data security problems, uneven resources availability, and the need to integrate digital literacy into accounting (Satjawisate et al., 2025; Tee et al., 2024; Nie and Mastor, 2024; Busulwa et al., 2026). There are also some human aspects to consider.

The present research focuses on investigating the factors that inhibit or facilitate the successful implementation of Computerised Accounting Systems in higher education accounting courses.

Statement of the Problem

While there is governmental backing for digitalisation of curricula, implementation of Computerised Accounting Systems (CAS) in accounting departments continues to remain inconsistent and inefficient. Ineffective ICT infrastructure, regular system downtime, poor technical support, and failure to integrate technology and accounting knowledge continue to

hamper the process. The financial accounting lecturers often lack necessary technological skills that will assist them in integrating the CAS platforms and IFRS. Cost of software licenses and cybersecurity concerns pose additional challenges, especially to public institutions.

The ideal situation is one in which modern CASs are integrated into the tertiary accounting curriculum to give students relevant digital skills while ensuring that the curriculum meets industry needs and closes the theory-practice gap. However, much of the current literature focuses on investigating individual barriers without looking at how all three of these barriers (infrastructure, faculty training, and management support) act together. Very few pieces of literature utilise statistical methods backed by theoretical concepts of TAM and institutional theory in tertiary institutions that are resource limited.

Objectives of the Study

The main aim will be an assessment of the factors and challenges associated with the adoption of Computerised Accounting Systems (CAS) in financial accounting education at tertiary level institutions. Specific objectives include:

- i. To assess the effect of the quality of technical infrastructure (hardware, software, stability of networks) on the effective adoption of CAS.
- ii. To identify the effect of training of teachers and their operational proficiency on the successful adoption of CAS.
- iii. To examine the effect of management support and funding for digitalisation in accounting departments.

Research Hypotheses

H₀1: Quality of technical infrastructure has no significant effect on the effective adoption of CAS in tertiary institutions.

H₀2: Training and operational proficiency of teachers have no significant effect on the adoption of CAS.

H₀3: Management support and funding has no significant effect on the digitalisation of accounting education.

Literature Review

Conceptual Review

Financial accounting education digital transformation is associated with the holistic incorporation of digital technologies aimed at changing instructional approaches, course development, and processes. A Computerised Accounting System (CAS) is the use of integrated software incorporating digital technology, processors, and databases to enter, process and analyse financial transactions (Aziz et al., 2026). In tertiary institutions, CAS serves as both

administrative tools and educational platforms that move accounting education from theoretical knowledge to actual data entry, reporting, and internal control assessment (Ojedele, 2023).

However, empirical evidence shows contradictory results. According to Machera and Machera (2017), university education programmes suffer from criticisms from employers due to the inability of graduates to apply their skills in practice due to non-computerised programmes. Digital transformation negatively impacted the quality of accounting information systems in emerging economies for a certain period (Hamdy et al., 2025). Insufficient upskilling, poor cybersecurity practices and lack of vendor assistance were the major barriers (Miller, 2025). On the other hand, investigations conducted in well-resourced settings (Alenezi, 2023; Al-Fraihat et al., 2020) have revealed that upon meeting certain threshold levels, adoption becomes much easier. Such contradictory evidence demonstrates the significance of conducting context-based multidimensional analysis in poorly resourced environments.

Theoretical Review and Conceptual Framework

The research will be based on the Technology Acceptance Model (TAM) and Institutional Theory.

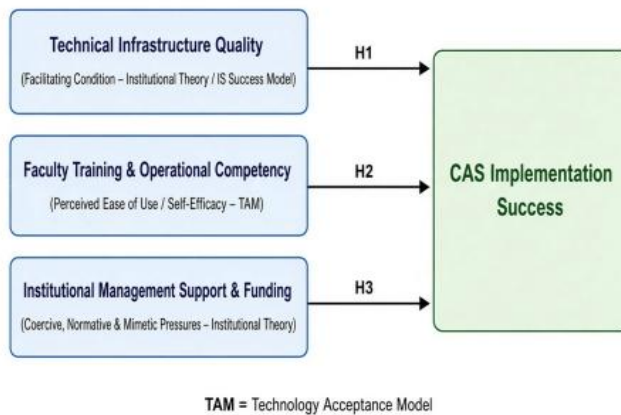
According to Davis (1989) TAM's usefulness and ease of use determine the users' intention to use a certain technology. In the context of education, faculty training and operational competency determine PEOU and computer self-efficacy; thus, if lecturers find it difficult to use CAS or do not see a link between it and learning outcomes, their intention to use it will be low (Fathema et al., 2015; Aziz et al., 2026).

The Institutional Theory (DiMaggio and Powell, 1983) focuses on explaining the influence of external regulations, socio-economic conditions, and institutional management on the adoption of innovations. The coercive, normative, and mimetic pressures affect institutions' decisions to use and maintain CAS.

Both these theories complement each other: While TAM explains individual level acceptance, the Institutional Theory explains the organisational environment necessary for this acceptance to happen. Both of them are more suitable than UTAUT and TOE frameworks as the study tries to explain the acceptance of educators as well as the institutional barriers of public tertiary institutions in developing countries.

Figure 1

Figure 1: Conceptual Framework



Conceptual Framework of the Study

Figure 1 presents three independent variables, namely, Technical Infrastructure Quality, Faculty Training & Operational Competency, and Institutional Management Support & Funding, which point to the dependent variable CAS Implementation Success, where the theories of the variables are shown.

Research Gap

Table 1. Summary of Selected Prior Studies and Remaining Research Gaps

Study	Key Variables	Context	Method	Main Finding	Remaining Gap
Machera & Machera (2017)	Curriculum, software exposure	Botswana	Qualitative	Persistent skills gap	No multi-factor quantitative model
Hamdy et al. (2025)	Digital transformation, AIS quality	Developing countries	Survey	Negative short-term effect	Focus on infrastructure only; omits faculty & management
Miller (2025)	Upskilling, cybersecurity	South Africa (telecoms)	Case study	Training & support bottlenecks	Single industry; no integrated regression model
Present study	Infrastructure + Training + Management support	Nigerian tertiary institutions	Multiple regression	All three significant; infrastructure strongest	Integrated theory-driven model in accounting education

Few studies have simultaneously examined technical, human, and institutional predictors of CAS implementation success in tertiary accounting education using a theory-driven multiple-regression approach. This study fills that gap.

Methodology

Research Design

A descriptive survey research design was adopted to gather cross-sectional data on institutional readiness and technical challenges.

Population and Sampling

The target population consisted of about 180 lecturers of accounting, laboratory administrators, and IT staff from various public and private tertiary institutions in the study area. Using the Krejcie and Morgan (1970) sample-size table, a population of 180 at a 95% confidence level and a 5% margin of error yields a required sample of 123. For this study, a purposive (judgmental) sampling method with 123 subjects was used in order to include only those subjects who have firsthand knowledge of teaching financial accounting courses or administration of the laboratory system. The focus was on information richness rather than on statistical generalisability. Post hoc power analysis with G*Power 3.1 showed power greater than 0.99 for observed effect sizes.

Research Instrument

A structured questionnaire with 22 questions measuring on a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) was formulated. The constructs and sources used are:

Tech_Inf (6 items): Adapted from Al-Fraihat et al. (2020), DeLone & McLean (2003). Sample item: "Network connectivity in the accounting laboratory is reliable during practical sessions."

Fac_Train (6 items): Adapted from Fathema et al. (2015). Sample item: "I have received adequate training to teach using modern CAS packages."

Inst_Sup (5 items): Taken from Institutional Theory and Venkatesh et al. (2003). Sample item: "Senior management allocates sufficient budget for CAS software licences and upgrades."

CASImp (5 items). Sample item: "CAS is successfully integrated into the financial accounting curriculum."

The content validity of the questionnaire was established by a panel of three accounting education experts and two IT experts. Face validity was confirmed through a pilot test involving 25 participants other than those in the main survey. Cronbach's alpha coefficients for Tech_Inf, Fac_Train, Inst_Sup, and CASImp were .87, .84, .81, and .86, respectively, all above the standard cut-off value of .70. Average Variance Extracted (AVE) values were greater than .50 for all constructs.

Data Analysis

The multiple linear regression model was specified as:

$$CAS_{Imp} = \beta_0 + \beta_1 Tech_Inf + \beta_2 Fac_Train + \beta_3 Inst_Sup + \epsilon$$

Where:

CAS_{Imp} = successful implementation of Computerised Accounting system (Dependant variable)

$Tech_Inf$ = Technical infrastructural quality

Fac_Train = Faculty training and operational competency

$Inst_Sup$ = Institutional management support and funding

β = Intercept parameter

$\beta_1, \beta_2, \beta_3$ = Regression coefficient of the independent variables

ϵ = Stochastic error term

Regression assumptions were tested and satisfied:

Multicollinearity: all Variance Inflation Factors (VIF) < 2.1 and tolerance > 0.48;

Normality of residuals: Shapiro–Wilk test $p > 0.05$ and acceptable Q–Q plots;

Homoscedasticity: Breusch–Pagan test $p > 0.05$;

Independence of errors: Durbin–Watson statistic = 1.92;

Linearity: residual plots showed no systematic patterns.

Results

Table 2

Multiple Linear Regression Results Predicting CAS Implementation Success

Variable	Unstandardised B	SE	Standardised β	T	P	95% CI	VIF
Intercept	0.412	0.115	—	3.582	< .001	[0.184, 0.640]	—
Technical infrastructure (Tech_Inf)	0.537	0.064	0.498	8.391	< .001	[0.410, 0.664]	1.42
Faculty training (Fac_Train)	0.339	0.051	0.312	6.647	< .001	[0.238, 0.440]	1.38
Institutional support (Inst_Sup)	0.211	0.048	0.189	4.395	.018	[0.116, 0.306]	1.29

Model summary: $R = 0.845$, $R^2 = 0.714$, adjusted $R^2 = 0.702$, $F(3, 116) = 96.42$, $p < 0.001$.

All three null hypotheses are rejected.

Discussion of Findings

The model explains 71.4% of the variance in CAS implementation success. Although high for a survey-based study, this magnitude is comparable to those reported in analyses of coupled socio-technical systems (Al-Fraihat et al., 2020).

Quality of technical infrastructure was revealed to be the most powerful predictor ($\beta = 0.537$, $p < 0.001$). This finding supports the DeLone and McLean (2003) Information Systems Success Model, which suggests that system quality (reliability, performance and network robustness) is an important pre-condition of user satisfaction and system usefulness. Without robust hardware, software and connectivity, there would be no pedagogical gain. The finding is also consistent with Alenezi (2023) and Al-Fraihat et al. (2020), who have found that technical facilitating conditions are the main predictors of engagement with complicated learning applications. In low-resource tertiary institutions, this would be the most significant barrier.

Competency in faculty training and operations was the second important factor ($\beta = 0.339$, $p < 0.001$). Within the TAM context, systematic professional development positively contributes to the perception of ease of use and computer self-efficacy (Fathema et al., 2015). If instructors have no sufficient knowledge of automation tools and contemporary cybersecurity issues, the level of teaching is poor, and students are poorly prepared. This confirms Miller (2025) and Alenezi (2023), who point out that human competencies are what actually transform technological possibilities into educational outcomes.

Support from institutional management and financial resources, though important ($\beta = 0.211$, $p = 0.018$), had relatively low impact. This is supported by the findings in the UTAUT theory, where management support is a facilitating condition (Venkatesh et al., 2003). The persistent support from the management is vital to get constant licensing, technical personnel, and readiness to accept the change, thus avoiding post-implementation obsolescence (Al-Fraihat et al., 2020).

As a whole, the findings indicate that CAS adoption is indeed a socio-technical activity that demands equal emphasis on technology, people, and organisational aspects. Attempts at adopting CAS without considering all of these will most probably fail.

Conclusion

The results disprove all three null hypotheses and indicate that successful implementation of CAS is dependent on the interrelated influence of infrastructure, faculty training and management support. Good quality of infrastructure is the basic condition; professional training of teachers turns technical possibilities into educational opportunities; and management support is required for financial sustainability and acceptance. Digital transformation in accounting education thus requires an approach that is comprehensive as opposed to being fragmented.

This study provides a clear roadmap for academic deans, policymakers, and university administrators. Failure to address these infrastructural inadequacies and the skills deficit among teaching staff will result in poor learning conditions and wasted resources. On the other hand, having a dependable CAS infrastructure will prepare students with the necessary competencies needed by employers in contemporary times.

Recommendations

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

Institutions of higher learning need to upgrade their IT architecture, ensure dependable cloud connectivity and installation of backup power generators to prevent any disruptions in practical classes.

Continuous training programme for financial accounting teachers on new software versions and cyber security measures needs to be mandatory and made part of their KPIs.

Departments of accounting need to enter into alliance with software companies and professional bodies in order to get educational licenses and realistic cases from corporates.

Institutions need to allocate budget for sustained funding of digital accounting efforts and not let it become obsolete.

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Artificial Intelligence-Driven Educational Transformation: A Review of Emerging Technologies and Their Impact on Teaching and Learning

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Abstract

Artificial Intelligence (AI) is increasingly reshaping educational systems by introducing innovative technologies that support teaching, learning, and educational management. This study aimed to examine the artificial intelligence-driven educational transformation and its impact on teaching and learning. A review research approach was employed in this study, drawing on recent scholarly articles, conference papers, institutional reports, and other relevant academic sources on AI applications in education. The result reveals that AI is being utilised in diverse areas, including personalised learning, intelligent tutoring systems, automated grading, learning analytics, curriculum development, special education support, and distance learning. These AI technologies enable learning experiences to be tailored towards individual student needs, provide timely feedback, enhance learner engagement, and support evidence-based educational decision-making. The reviewed studies also indicate that AI can reduce teachers' administrative workload and improve access to quality education for students with varying abilities and learning backgrounds. The review further revealed that, despite the significant benefits of artificial intelligence in enhancing teaching, learning, and educational management, its adoption is constrained by challenges such as data privacy concerns, algorithmic bias, inadequate digital infrastructure, ethical issues, and limited AI literacy among educators. The study concludes that governments, educational institutions, and technology developers should collaborate to establish robust policies, invest in digital infrastructure, and promote AI literacy to ensure the responsible, inclusive, and sustainable integration of artificial intelligence into education.

Keywords: Artificial Intelligence, Educational development, Intelligent Tutoring Systems, Learning Analytics, Personalised Learning

Introduction

Education remains one of the most important drivers of human capital development, socioeconomic progress, and sustainable national development, providing individuals with the knowledge and skills required to thrive in an increasingly digital society (Selwyn, 2022). The rapid evolution of digital technologies has transformed educational systems worldwide by reshaping curriculum delivery, learning environments, and the interaction between teachers and learners, thereby promoting more flexible and learner-centred education (Holmes, Bialik, and Fadel, 2022). Among these technological innovations, artificial intelligence (AI) has emerged as a transformative technology capable of enhancing teaching and learning through intelligent tutoring systems, adaptive learning platforms, automated assessment, and learning analytics (Zawacki-Richter et al., 2019). As reported by Brown, Myers and Roy (2003), the increasing complexity of educational challenges has stimulated the search for innovative technological solutions capable of improving teaching, learning, assessment, and educational management. Recent advances in digital technologies, particularly artificial intelligence (AI), have created new opportunities to address many of these challenges by supporting personalised learning, intelligent tutoring, automated assessment, learning analytics, and inclusive education. Consequently, AI is increasingly being recognised as a transformative technology that complements traditional educational practices and enhances the quality, accessibility, and efficiency of education across different learning environments (Hongwei et al., 2023). Against this background, this study critically reviews recent developments in the application of artificial intelligence in education, with particular emphasis on its applications, benefits, implementation challenges, and future prospects for improving teaching, learning, assessment, and educational management.

Statement of the Problem

Despite the increasing adoption of artificial intelligence (AI) in education, its implementation remains uneven due to challenges such as ethical concerns, data privacy issues, inadequate digital infrastructure, and limited AI literacy among educators. Existing studies have largely focused on specific AI applications without providing a comprehensive synthesis of their benefits, challenges, and future prospects. Consequently, there is a need for an up-to-date review that critically examines recent developments in AI-driven educational technologies. This study addresses this gap by synthesising current evidence on the applications, opportunities, challenges, and future directions of AI in education to provide guidance for researchers, educators, and policymakers.

Aim of the Study

The aim of this study is to critically review recent developments in the application of artificial intelligence in education, with emphasis on its applications, benefits, challenges, and future prospects for enhancing teaching, learning, and educational management.

Objectives of the Study

The specific objectives of this study are to:

- examine the applications and benefits of artificial intelligence in teaching, learning, and educational management;
- identify the challenges associated with the adoption and implementation of artificial intelligence in education; and
- evaluate recent developments and future prospects of artificial intelligence for improving educational systems.

Research Methodology

This study adopted a systematic literature review (SLR) approach guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to examine recent developments in the application of artificial intelligence (AI) in education. Relevant literature published mostly between 2017 and 2026 was retrieved from reputable databases, including Scopus, Web of Science, IEEE Xplore, ScienceDirect, SpringerLink, ACM Digital Library, ERIC, and Google Scholar. The search covered peer-reviewed journal articles, conference proceedings, academic reports, books, and institutional publications focusing on AI applications in education. Keywords such as “Artificial Intelligence in Education,” “Machine Learning in Education,” “Generative AI,” “Intelligent Tutoring Systems,” “Adaptive Learning,” “Learning Analytics,” and “Educational Data Mining” were combined using Boolean operators (AND, OR, and NOT) to improve search accuracy and coverage.

The study selection process followed the four stages of the PRISMA framework: identification, screening, eligibility, and inclusion. A total of 120 records were initially identified and downloaded from the selected databases. During the identification stage, 17 duplicate records were removed, leaving 103 unique records for screening. The titles and abstracts of these records were screened based on their relevance to the study objectives. Studies that were unrelated to AI in education, non-English publications, editorials, and records that did not provide relevant information were excluded. The potentially relevant studies were subsequently assessed against the predefined eligibility criteria, resulting in 53 studies being selected for the final review.

The inclusion criteria covered peer-reviewed journal articles, conference papers, and review articles written in English that examined the application of AI in teaching, learning,

assessment, educational management, and student support. Studies were excluded if they were duplicated, unrelated to the research objectives, or did not provide sufficient information relevant to AI in education. Information extracted from the selected studies included authors and publication year, research objectives, research methodology, AI technologies or techniques used, major findings, and recommendations. The extracted information was synthesised using thematic analysis and organised into major themes, including AI applications, personalised learning, intelligent tutoring systems, automated grading and assessment, learning analytics, curriculum design, special education support, distance learning, implementation challenges, ethical concerns, and future research directions. The application of the PRISMA framework enhanced the transparency and systematic nature of the study selection process, while the thematic synthesis provided a comprehensive understanding of current developments and challenges associated with the integration of AI into education.

Results and Discussion

This section presents results and discussion in two perspectives – application of AI in teaching, learning and educational management, and challenges of artificial intelligence in education.

Applications of Artificial Intelligence in Teaching, Learning and Educational Management

Results and discussion on the application of AI are made hereunder along the following themes:

Personalised Learning

Personalised learning is defined as the process of tailoring instruction, learning activities, and educational resources to suit individual learners, allowing them to learn at their own pace and according to their specific strengths and weaknesses. This approach helps students learn more effectively by focusing on their strengths while providing additional support in areas where they face difficulties. Zawacki-Richter et al. (2019) found that personalised learning is defined as the modification of educational materials to suit individual student needs, academic levels, and interests. In terms of its importance, personalised learning enhances student motivation and engagement with the curriculum, which will lead to improved academic understanding. Furthermore, Al-Nabhani et al. (2025) stated that personalised learning can be described as a learning predicated on the notion that each student has distinct capacities and talents, which necessitate an educational system tailored to address these particular requirements, hence producing desirable education. In simple terms, it promotes customised educational experiences for each student according to their individual requirements and interests.

Merino-Campos (2025), stated that integrating artificial intelligence in education has the capability to revolutionise personalised learning by adapting content, instructional methods, and pace to the individual needs of students. The work further indicates that AI technologies can significantly optimise educational outcomes by tailoring content as well as the feedback to

individual learner needs. Malami (2024) observed that artificial intelligence-based tutoring systems can enhance the learning experience by supporting personalised learning, generating educational resources, and developing learning materials that respond to the diverse needs of students.

As reported by Salameh (2024), AI technologies like intelligent tutoring systems, adaptive learning platforms, and data analytics tools create a tailored pathway that can accommodate learning differences, increase participation and improve academic outcomes. The author added that one of the features of adaptive learning systems is that they provide real-time feedback and customised resources, allowing students to learn at their own pace. It was further stated by the author that, though findings indicate that while AI can enhance personalised learning, it needs careful integration in order to support critical thinking.

Yarlagadda (2025) reported that artificial intelligence is transforming education through various means, such as personalised learning experiences and intelligent tutoring systems. Thus, by applying machine learning algorithms, adaptive platforms analyse the data of students' performance to customise content difficulty, pacing, and presentation methods according to the needs of individuals. The work added that the integration of AI in education has resulted in a significant advancement toward personalised learning at scale while maintaining the essential elements of the educational process. Similarly, Calvo (2025) revealed that artificial intelligence is contributing in a great way to educational system development across the globe through personalised learning system creation. Also, AI visualisation of education based on individual student requirements helps in the improvement of performance and better student participation in learning activities. Apelehin et al. (2025) noted that the integration of artificial intelligence (AI) in personalised learning and education has proved to be a transformative force, reshaping traditional teaching methods and adapting to the diverse needs of learners. This is as a result of AI's ability to analyse vast amounts of data, which enables the creation of personalised learning paths. It added that machine learning algorithms can identify areas of difficulty, assess students' progress, and recommend targeted resources. This method helps each learner receive content at an optimal pace, promoting a more effective and engaging learning experience.

In the work by Alakayleh (2025), it was highlighted that the rapid advancement of generative AI, multimodal systems, and adaptive platforms ensures that personalised learning is no longer an abstract ideal but a practical reality. Their findings report that AI-enhanced personalised education improves academic performance and reduces achievement gaps, as well as fosters student engagement. In a systematic review and analysis of a large body of literature on AI-based personalised learning using specific inclusion and exclusion criteria (Farhood, 2025), the results support the assertion that personalised learning has evolved into a core concept in educational technology research. The analysis revealed that while customised learning is now feasible, it remains one of the most significant matters in contemporary educational institutions.

As reported by Fatma and Batdi (2024), artificial intelligence has entered the classrooms and is transforming education worldwide under the umbrella of personalised learning systems. The authors added that artificial intelligence has opened new dimensions in education through the collection and analysis of vast amounts of data generated by each student. As reported by Anderson and Kerr (2022) and Birma, Gora & Zarma (2025), AI-driven tutoring systems such as intelligent tutoring systems have developed a greater acceptance across global educational landscapes, displaying promising results in enhancing the learning outcomes of students. This approach is designed to improve student engagement and retention by adapting content to the learner's needs in real time, given that in personalised learning, students receive tailored instructional support, addressing their individual strengths and weaknesses. There is a revolutionisation of personalised learning by leveraging advanced artificial intelligence technologies such as natural language processing, machine learning, and adaptive learning models. Personalised learning is designed to dynamically adjust to the preferences, unique needs, and learning pace of individual users, thus enhancing educational effectiveness through tailored pedagogical strategies (Das et al., 2025). By analysing student performance patterns, these tools can support adaptive learning environments and provide tailored learning recommendations. This is because AI technology promotes data-driven decision-making and personalised learning. (Shubha et al., 2026; UNESCO, 2023)

Intelligent Tutoring Systems

Intelligent Tutoring Systems can be defined as the educational tools designed to provide learners with guidance and support similar to what they would receive from a human tutor. These systems assist students in understanding concepts, solving problems, and improving their knowledge through interactive learning experiences. One of the most notable applications of AI in higher education is intelligent tutoring systems, which replicate one-to-one human tutoring for learners by offering adaptive, context-sensitive feedback (Kamalov et al., 2023; Almutairi, 2025), which will enhance the engagement by the learners. Omeh (2026) emphasised that educators can utilise intelligent tutoring systems and other AI platforms to enhance engagement and improve assessment quality in web design and development. The study also emphasises the importance of designing assessments that align with AI capabilities to ensure equitable support for all students or learners.

Similarly, Yarlagadda (2024) stated that artificial intelligence tutoring systems can be designed to give the students help with questions and advice and do not need to have an instructor intervene or support in any way before the aim is achieved. With this method, whenever the learners have issues in any aspect of their studies, they can always get help, and this will boost their learning. As observed by Ajuwon et al. (2024), in the context of education, artificial intelligence is applicable in areas like intelligent tutoring systems, predictive analytics, and automated administrative tools, and these are all important for the growth and development

of education, especially as they reduce the active participation or intervention of a physical tutor. In their work, Ahmad et al. (2024) stated that intelligent tutoring systems and other applications of AI are greatly assisting the academic activities and tasks of a teacher across the globe. It is reported that AI applications help teachers to teach in a better way, reduce the burdens, and increase the time for teaching and guiding. In addition, AI systems also reduce institutional operating costs, assist in facility management, and improve their responsiveness, the author added.

From the works by Chen et al. (2020) and Vieriu and Petrea (2025), it was observed that applications such as intelligent tutoring systems, educational robots, learning analytics dashboards and human computer interactions have displayed significant potential for the enhancement of learning and teaching. In the work by Hang et al. (2024) and Merino-Campos (2024), the use of intelligent tutoring systems, which explore adaptive feedback of machine learning or AI, has shown measurable improvements in the performance of learners. AI technologies such as adaptive learning systems combined with intelligent tutoring applications modify instruction when students demonstrate performance assessment. With this, students can develop skills for self-adaptation through custom learning approaches and also enable the fast feedback through these systems that encourages learners to embrace the education learning styles (Salameh, 2024; Calvo, 2025).

Automated Grading and Assessment

Automated grading and assessment can be defined as the use of computerised systems to evaluate students' academic work instead of relying entirely on manual marking by teachers. This approach helps speed up the assessment process, provides timely feedback to learners, and reduces the workload associated with grading large numbers of students. In the research by Gaikwad (2025), it was reported that AI-driven tools like chatbots, intelligent tutoring systems, and learning analytics help provide real-time support, tailor content to individual learners' needs, and track progress, which improves both engagement and outcomes. Additionally, AI can automate administrative processes such as student enrolment, grading, and feedback, leading to increased productivity and reduced manual work for educators. Confirming the above result, Yaseen et al. (2024), in their research, observe that AI technologies can reduce the administrative burden on ODL institutions by automating tasks such as grading, scheduling, and student support. In the views of Buame (2025), advanced AIs can help students or learners study by providing additional educational opportunities, analysing the engagement of learners, and providing personalised feedback in a way that helps to monitor student behaviours, alert professors and administrators to those at risk, assist in online instruction, and facilitate online proctoring through facial recognition. Also, Selwyn (2019) and Barman et al. (2026), observed that artificial intelligence helps reduce teachers' workload through automation processes such as

grading tests and scheduling. This allows teachers to focus on teaching and curriculum planning, thereby improving the efficiency and performance of the teachers or school administrators.

In the same way, Heffernan and Heffernan (2014), and Mohammad (2025) reported that artificial intelligence has been used efficiently in education systems in areas such as grading essays, automated testing, and automatically creating multiple-choice tests. This does not only reduce the teacher's workload, but they also offer the students immediate feedback. Also, AI tools have demonstrated that they have the capabilities to significantly reduce the time teachers spend grading assignments, thus allowing them to focus more on student engagement. The time taken to mark, record, and compile is much longer, especially in the case when the students are many, but with the aid of automated grading, the load is reduced and will help in making available times for other activities in the class or with the learner. In the study by Ajuwon et al. (2024), it was established that most conventional grading systems involve tedious computation by the instructors and sometimes cannot be used to grade large classes and may yield different scores for the same work in other courses. To solve this problem, the application of artificial intelligence (AI) in educational assessments may be useful as it can improve the process. Automated grading also means that teachers are sparing their time and making a useful investment in students' feedback, which is vital for the learning process. Ideally, in the traditional learning environment, students wait days or weeks to receive feedback on their academic work. Feedback flow—With the help of AI, it is possible to provide instant feedback, which the students can solve quickly (Yarlagadda, 2024; Tian et al., 2025). Muhammad et al. (2024) noted that AI is being used in the education field, as evidenced by global initiatives such as UNESCO, because of its numerous advantages. They also noted that AI applications in the education field include enabling the preparation of content, assignments, automated grading, and assistance to students, given that AI automated grading can grade nearly fill-in-the-blank and all kinds of multiple-choice testing.

Learning Analytics

Learning analytics is defined as the process of collecting and examining information about the learners and their learning activities in order to better understand how learning takes place. By analysing data such as performance and learning behaviour, teachers can identify areas where the learners may need support and make informed decisions that improve teaching and learning outcomes. According to Tuomi (2018), as it is possible for one teacher to teach very many students in online environments but difficult to know what the students learn, one of the great promises of AI is to do large-scale learning analytics in such environments, given that learning analytics allows the systematic examination of educational data generated during the learning process in order to understand learner behaviour, monitor progress, and support informed educational decision-making. In the work by Barman et al. (2026), the author stated that AI tools, especially learning analytics-based tools, have the capability of processing vast

amounts of data related to students' learning behaviour, such as their academic performance and behavioural interactions. In essence, AI has the potential to revolutionise the curriculum design process in a dynamic, inclusive, and future-focused manner, which will help to improve teaching and learning in a great way.

In order to remain effective, AI algorithms are continuously improved to guarantee increased accuracy in administrative work, learning analytics, and student assessments. Also, it was noted that the efficacy of AI-driven solutions can be improved through frequent feedback loops, which will involve the students and the educators. This was the observation by Katiyar and Tiwari (2024). Assessing the importance of learning analytics in education, Yousef (2023) reported that learning analytics in educational management can enable institutions to make data-informed decisions and provide targeted support to students and teachers, and this will result in the achievement of educational goals or intended objectives of the system. In the study by Mohd. et al. (2026), the work showed that AI machine learning has been combined with learning analytics dashboards and educational technology platforms to establish a new paradigm. This is to create an environment where data drives the process of teaching and learning instead of intuition, leading to quantifiable positive outcomes of the performances of students or learners irrespective of fields. Alkan (2024), observed that learning analytics, adaptive tutorial systems, expert systems, dialogue-based systems, and educational data mining are widely used AI systems that were developed to increase efficiency in educational environments, enable the receiving of instant feedback, and enrich student interaction. It was added that assessing the learning inclinations, weaknesses, and strengths of the students enables AI to provide tailored learning content and resources that cater to their individual requirements effectively.

Curriculum Design

Curriculum design is defined as the process of planning and organising what students are expected to learn within an educational programme. It involves selecting appropriate learning objectives, content, teaching methods, and assessment strategies that will help learners achieve desired educational outcomes. As noted in the research by Johnson et al. (2017), AI can streamline the curriculum design process, allowing educators to focus on pedagogical strategies rather than administrative tasks. Curriculum is one of the major materials in educational systems, whether at the primary, secondary, or tertiary level, and its design is very crucial as it determines what is taught or learned in the school. Also, Baker and Smith (2019) reported that AI technologies, including machine learning algorithms, natural language processing, and data analytics, have been critical in curriculum development. The work added that AI machine learning, for instance, has enabled the creation of adaptive learning platforms that analyse student interactions and performance to customise the curriculum in real time. In the views of Toyokawa et al. (2023), with strategic investment in training, curriculum design, and stakeholder collaboration, including the involvement of parents, artificial intelligence can become a

paramount catalyst for empowerment and equity in educational development. In the same way, Kasztelnik (2024) noted that the advancement of artificial intelligence technology has resulted in a new wave of innovation in education, especially in curriculum development. The author further reported that by utilising AI to enhance curriculum design, educators can easily prepare students for the complexities of the contemporary world, fostering lifelong learning and adaptability in an ever-evolving global environment.

Olumoyo (2025), stated that AI has been observed to be an advanced technology that is capable of managing education for curriculum planning, skills development, enhancing the learning process, improving student outcomes, and easing administrative tasks. It can also assist teachers in curriculum development and drawing quizzes or tests for the pupils. As noted by Omeh (2026), AI-assisted assessment helps manage cognitive load by providing immediate, targeted feedback during the learning process, thereby reducing unnecessary mental strain and supporting germane cognitive load. The work also reported that AI technology with pedagogical intent has the potential to foster deeper learning, reduce cognitive overload, and enhance development. Barman et al. (2026), in their study, maintained that artificial intelligence as a technological innovation is transforming the field of curriculum development through a more personalised, effective, and responsive curriculum development process. The strategies identified in their study included learning analytics, teacher training, ethics, and industry engagement, and they concluded that AI has the potential to revolutionise the curriculum design process in a dynamic, inclusive, and future-focused manner. AI technologies, such as machine learning and data analytics, can identify student learning patterns, evaluate performance in real-time, and recommend relevant materials that will be suitable to the learners, thus making learning more effective. It was highlighted that AI assists educators in developing curricula, especially those that are relevant to technological advancements and industry needs, and this makes the educational system more responsive to global challenges and improves graduate competitiveness (Suja et al., 2025). In the work by López et al. (2021), it was reported that AI predictive analytics supports strategic planning by providing insights into various aspects of institutional performance, especially the insights that can be used by the institutions to make data-driven decisions about curriculum development and the general institutional goals.

Special Education Support

Special education support can be defined as the services, resources, and instructional practices provided to learners who have unique educational needs such as students with physical disabilities, learning difficulties, developmental conditions, or other challenges that affect learning. The aim is to ensure that every learner has equal opportunities to learn and have access to the educational system. As reported by Harkins-Brown et al. (2024), AI can address persistent challenges in special education, such as strengthening individualised education programmes and automating routine tasks, as well as providing adaptive interventions for diverse learner needs,

which will help in increasing teachers' efficiencies. It was also reported that making use of AI in special education often involves leveraging sensitive student data, including disability type, assessment results, student behaviours, and disability information. In the words of Marouf et al. (2024), the rapid evolution of generative artificial intelligence has created an unprecedented opportunity and enabling environment to transform teaching and learning, particularly in special education, to a productive level irrespective of the level or stage of the education.

In their observation, Goldman et al. (2024) asserted that the nationwide shortage of special education teachers, shown in various research studies that were said to be caused by increasing workloads, might be reduced through the integration of AI. In a simple term, AI has been suggested as an intervention to reduce the workload of special education teachers. In a similar way, Garg and Sharma (2020) noted in their research that AI significantly enhances special education by delivering individualised and adaptable learning experiences customised to the distinct needs of children with disabilities. They added that AI-driven systems may evaluate individual learning styles and challenges, allowing educators to formulate tailored educational tactics that enhance engagement and academic achievement. As noted by Nair et al. (2024), AI tools such as machine learning and others have the capabilities to significantly improve academic engagement and outcomes for students with disabilities. Also, AI can address persistent challenges in special education, including automating routine tasks, strengthening individualised education programmes, helping in providing adaptive interventions for diverse learner needs, and increasing teacher efficiencies. Although, AI can offer substantial support, it should be integrated thoughtfully, guided by empirical research, and accompanied by skilled professional oversight to ensure that it truly benefits students with disabilities. (Harkins-Brown et al., 2025).

According to the study by Devadas (2025), it was highlighted that the integration of AI technologies in educational contexts represents a major important discovery in how we conceptualise and deliver special education services. They also reported that AI-augmented education deals with the strategic implementation of artificial intelligence tools and methodologies to enhance teaching and learning processes, with particular emphasis on addressing the unique challenges faced by children with special needs, thus solving the common problems of those in the special education group. All these materials reviewed have shown how important AI technologies are in special education, and this implies the growth in education.

Distance Learning

Distance learning is defined as the form of education in which teaching and learning take place without the teacher and students being physically present in the same location. The mode of learning provides flexibility and has become an important means of expanding access to education for people who may not be able to attend traditional classroom settings. The integration of AI into online learning environments has transformed distance education by enabling personalised instructional support, improving institutional efficiency, and strengthening

learner participation. In a study conducted by Gaikwad (2025), it was reported that the application of Artificial Intelligence (AI) in Open and Distance Learning (ODL) has gained significant attention in recent years as a result of its potential to enhance educational outcomes. The study further reveals that AI technologies are being increasingly integrated into learning platforms, which help to automate administrative tasks and deliver personalised learning experiences, as well as improving student engagement and retention. Tian (2022), reported that the integration of AI and the corresponding distance learning platform can allow the platform to carry out real-time and dynamic supervision and monitoring of all learners' learning behaviours and teachers' counselling behaviours. It was also reported that it can help in the proper planning of specific learning guidance based on learners' actual learning conditions and learning progress and provide reasonable intellectual support for teachers' counselling work.

As noted by Hongwei et al. (2023), the application of artificial intelligence technology in the educational system will promote distance education activities to gradually generate a large amount of data, which can often have a decisive impact on the effectiveness of distance education, such as learners' learning feedback and evaluation information, learning status information, and performance information. Satish (2025) observed that the application of artificial intelligence in open and distance learning has gained significant attention in recent years due to its potential to enhance educational outcomes. It was later observed that the integration of AI technologies into learning platforms is helping to deliver automated administrative tasks and improve student engagement and retention. Alkan (2024) observed that AI expert systems, which are interactive and reliable computer-based decision-making systems, are also used in distance education. It was added that these expert systems have the structures that expand the knowledge base and improve decision-making mechanisms with the personalised feedback they offer to students in distance education and the answers they obtain through problems. All these sources have stated how relevant AI technologies are in distance education or distance learning, and by extension, educational development.

The reviewed literature demonstrates that artificial intelligence has become an important driver of innovation in education by enhancing personalised learning, intelligent tutoring systems, automated assessment, learning analytics, and educational management. Most studies consistently reported that AI improves students' learning experiences, supports educators in instructional delivery, and increases administrative efficiency. However, the findings also indicate that the effectiveness of AI applications largely depends on the availability of quality data, adequate digital infrastructure, institutional readiness, and users' digital competencies. Despite the significant progress reported in recent studies, several challenges remain unresolved. Ethical concerns relating to data privacy, algorithmic bias, transparency, academic integrity, and unequal access to AI technologies continue to limit widespread adoption, particularly in developing countries. Furthermore, many existing studies focus on evaluating individual AI tools

rather than providing comprehensive frameworks for sustainable AI implementation across educational systems.

Challenges of Artificial Intelligence in Education

Despite the numerous benefits of artificial intelligence (AI) in education, its widespread adoption is accompanied by several challenges that must be addressed to ensure its effective and responsible implementation. One of the major concerns is data privacy and security, as AI systems rely on large volumes of student data, making educational institutions vulnerable to unauthorised access, data breaches, and misuse of sensitive information. Ensuring compliance with data protection regulations and implementing robust cybersecurity measures are therefore essential. García-López and Trujillo-Liñán (2025) conducted a systematic review to examine the ethical and regulatory challenges associated with generative AI in education. The review synthesised evidence from 53 peer-reviewed studies and found that the increasing use of AI systems raises significant concerns regarding student data privacy, security, and regulatory compliance. The authors concluded that comprehensive governance frameworks and stronger data protection policies are essential for the responsible adoption of AI in educational institutions.

Another significant challenge is algorithmic bias and fairness. AI models are trained using historical datasets, which may contain biases that can lead to unfair decisions in student assessment, admission processes, and personalised learning recommendations. Such biases may disadvantage certain groups of learners and undermine trust in AI-driven educational systems. Consequently, developers and educators must ensure that AI algorithms are transparent, explainable, and regularly evaluated for fairness. Okuonghae et al., (2025) investigated the influence of AI algorithm bias awareness and ethical concerns on the use of artificial intelligence for information retrieval among Library and Information Science students in Nigeria. Using a correlational research design involving 213 respondents, the study found a significant relationship between students' awareness of algorithmic bias, ethical concerns, and their use of AI tools. The authors concluded that although students widely adopted AI for academic purposes, fairness, transparency, and ethical AI practices are essential for promoting responsible and equitable AI use in education. The digital divide also remains a critical barrier to AI adoption in education. The review found that while AI supports personalised learning and broader educational access, disparities in digital infrastructure, internet connectivity, and AI literacy continue to widen the digital divide. The authors recommended equitable investment in digital infrastructure and inclusive AI policies to ensure fair access to AI-enabled education.

Furthermore, the integration of AI into education raises concerns regarding academic integrity and ethical use. The increasing use of generative AI tools has created opportunities for plagiarism, automated assignment completion, and misinformation, making it more difficult for educators to assess students' original work accurately. These concerns highlight the need for

clear institutional policies, ethical guidelines, and responsible AI practices that promote academic honesty while encouraging the productive use of AI technologies. García-López and Trujillo-Liñán (2025) reviewed ethical issues associated with generative AI in education and reported that the rapid adoption of AI tools has intensified concerns over plagiarism, misinformation, academic dishonesty, and excessive dependence on AI-generated content. The study emphasised the importance of institutional policies, ethical guidelines, and AI literacy programmes to promote responsible AI use in teaching and learning. Also, successful AI implementation depends on teacher preparedness and institutional readiness. Many educators lack the necessary knowledge and technical skills to effectively integrate AI into classroom activities. Continuous professional development, curriculum redesign, and supportive institutional policies are therefore required to maximise the educational benefits of artificial intelligence while minimising its associated risks. Cheah et al., (2025) investigated teachers' preparedness, practices, and barriers to integrating generative AI into K–12 education through a mixed-methods study involving 89 teachers. The findings showed that many teachers lacked adequate AI knowledge and mainly used AI for lesson preparation rather than classroom instruction because of limited training, ethical concerns, and insufficient institutional guidance. The authors concluded that continuous professional development and supportive educational policies are essential for successful AI integration.

Conclusion

The research work was on determining how artificial intelligence-driven technologies are contributing to the educational transformation globally, especially in terms of their impact on the teachers and learners, or teaching and learning. The research adopted a review method to examine and analyse existing, relevant and recent works in the related area. It was observed from the literature that AI technologies are helping to create more personalised, efficient, and inclusive learning environments by employing some methods or applications such as intelligent tutoring systems, adaptive learning platforms, automated assessment tools, learning analytics, and AI-supported curriculum development for both effective teaching and student learning. The literature further indicates that AI can support educators by reducing routine administrative tasks, allowing greater attention to instruction, mentorship, and learner development. In addition, AI is also supporting the educational transformation through special educational needs and the delivery of distance as well as online education. Although this review demonstrates that artificial intelligence has the potential to transform education, its successful implementation depends on addressing challenges related to data privacy, ethical considerations, algorithmic bias, digital inequality, and teacher preparedness. Therefore, it is concluded that governments, educational institutions, and technology developers should collaborate to establish robust policies, invest in

digital infrastructure, and promote AI literacy to ensure the responsible, inclusive, and sustainable integration of artificial intelligence into education.

Summary of the Results

The reviewed findings indicate that Artificial Intelligence (AI) is increasingly transforming education through its application in teaching, learning, assessment, and educational management. The results show that AI-supported personalised learning enables educational content, learning pace, instructional methods, and feedback to be adapted to the individual needs, abilities, and weaknesses of learners. This improves student engagement, participation, and learning outcomes by providing targeted learning support (Merino-Campos, 2025; Yarlagadda, 2025). Similarly, intelligent tutoring systems provide learners with interactive guidance and real-time feedback, thereby supporting independent learning while reducing the instructional burden on teachers. Evidence from the reviewed studies further demonstrates that automated grading and assessment can reduce teachers' workload, accelerate the marking process, and provide immediate feedback to students, particularly in large classes.

The results also reveal that learning analytics and AI-based educational management tools facilitate data-driven decision-making by analysing students' academic performance and learning behaviours. These technologies can help educators identify students' strengths and weaknesses and provide appropriate interventions. AI also contributes to curriculum design by analysing learning patterns and recommending relevant educational resources, making curricula more responsive to learners and emerging technological and industry requirements. In addition, AI applications support special education and distance learning by providing adaptive interventions, personalised assistance, and improved learner monitoring.

Despite these benefits, the findings show that AI adoption in education is constrained by data privacy and security concerns, algorithmic bias, academic dishonesty, inadequate infrastructure, limited AI literacy, and insufficient teacher preparedness. The reviewed studies therefore suggest that successful AI integration requires strong ethical and regulatory frameworks, adequate digital infrastructure, continuous teacher training, and institutional support. In summary, AI has considerable potential to improve educational quality and efficiency, but its benefits depend on responsible, equitable, and well-planned implementation.

Recommendations

Based on the findings of this review, several recommendations are proposed to facilitate the effective and responsible integration of artificial intelligence into education. First, educational institutions should invest in reliable digital infrastructure and provide adequate technological resources to support the deployment of AI-enabled teaching and learning systems. Second, governments and educational policymakers should establish comprehensive policies and

ethical guidelines that address issues relating to data privacy, algorithmic transparency, fairness, accountability, and the responsible use of AI in educational settings.

Furthermore, continuous professional development programmes should be organised to equip educators with the knowledge and practical skills required to integrate AI technologies effectively into teaching, assessment, and educational management. Curriculum developers should also incorporate AI literacy into educational programmes to prepare students for an AI-driven society. Finally, researchers should continue to investigate emerging AI technologies, particularly explainable AI, generative AI, and human-centred AI, while conducting longitudinal studies to evaluate their long-term impact on teaching effectiveness, student learning outcomes, and educational equity.

Future Research Directions

Although considerable progress has been made in applying artificial intelligence to education, several research opportunities remain. Future studies should investigate the long-term effects of AI-assisted learning on students' academic performance, critical thinking, creativity, and knowledge retention across different educational levels. There is also a need to develop more transparent and explainable AI models that enhance users' trust while reducing algorithmic bias and improving decision-making in educational environments.

Further research should explore the integration of emerging technologies such as generative AI, multimodal learning systems, digital twins, blockchain, and the Internet of Things (IoT) to create more intelligent, secure, and personalised learning environments. Comparative studies across countries and educational contexts are also recommended to examine differences in AI adoption, policy implementation, and educational outcomes. Finally, future researchers should evaluate the ethical, legal, and social implications of AI in education and develop sustainable governance frameworks that promote responsible, inclusive, and equitable use of AI technologies in teaching, learning, and educational management.

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Handheld Mobile Devices, Artificial Intelligence, and Study Habits Among Secondary School Biology Students in Abia State, Nigeria

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Abstract

This study investigated handheld mobile devices and artificial intelligence as predictors of study habits among secondary school Biology students in Abia State, Nigeria. There were two research questions and two hypotheses. The population for the study was 13,947 Senior Secondary Three (SS III) students in public schools in Abia State, Nigeria in 2025/2026 academic session. A sample of 386 SS III students was drawn through the use of simple random sampling technique. Three instruments were used for the study. They included Handheld Mobile Devices Questionnaire (HHMDQ), Artificial Intelligence Questionnaire (AIQ), and Students' Study Habits Questionnaire (SSHQ). The instruments were validated by three experts. The instruments were subjected to reliability tests using Cronbach's Alpha formula. Reliability indices of 0.83, 0.70, and 0.89 were obtained for Handheld Mobile Devices Questionnaire (HHMDQ), Artificial Intelligence Questionnaire (AIQ), and Students' Study Habits Questionnaire (SSHQ) respectively. Pearson Product Moment Correlation was used to answer the research questions, while Simple Regression was used to test the null hypotheses at 0.05 level of significance. Results showed that Secondary School Students' use of handheld mobile devices significantly and positively predicts their study habits in Biology to a high extent. It was also found that Secondary School Biology Students' use of Artificial Intelligence significantly and positively predicts their study habits in Biology to a high extent. Based on the findings, it was recommended that government and school administrators should give guidelines on the use of handheld mobile devices and artificial intelligence among secondary school students in order to bring about good study habits.

Keywords: Artificial Intelligence, Biology, Handheld Mobile Devices, Information and Communication Technology, Study Habits

Introduction

Information and Communication Technology (ICT) has produced significant shifts in all spheres of human endeavours such as industries, agriculture, medicine, business, engineering,

and education. The effective integration of ICT into the teaching and learning process has the potential to engage learners, improve academic progress, encourage and motivate students, promote collaboration, supervisory research, and to develop new student-focused learning culture (Ezugwu and Ezeudu, 2022). It is important to bring the integration of information and communication technology ideas, materials and tools into school education because ICT allows teachers and learners to tailor teaching and learning to individual needs (Nnaekwe and Ugwu, 2019). According to Obeka (2019), information and communication technologies or electronic devices that are useful in teaching and learning include televisions, microphone, cell phones, radio, google slides, google meet, zoom, whatsapp, google scholar, among others. Some of these devices are handheld mobile devices while others are not.

Handheld mobile devices refer to information and communication technological gadgets that can be carried by hand or purse to assist/support learning anywhere and anytime. Ezugwu & Ezeudu (2022) stated that handheld mobile devices allow individuals to be more productive while consuming, interacting with, or creating information mediated through a portable digital device which has reliable connectivity that the individual carries on a regular basis, and fits in a pocket or purse. Bachore (2018) states that handheld mobile devices include cell phones, personal digital assistants (PDAs), smart phones, pads, pods etc. The main features of handheld mobile devices are accessibility, immediacy, and interactivity (Ogata and Yano, 2004). As cell phones, smart phones, ipads, tablets are readily available, learners can connect to internet and utilise the opportunity to learn often. It is also possible for learners to have adequate communication with each other, or with other colleagues and professionals in different locations through the use of handheld mobile devices which have various applications.

Learning through handheld mobile devices provides the learners with the opportunity to learn easily when they are in a vehicle or anywhere outside the classroom, thus learning can take place everywhere and at any time. The use of handheld mobile devices in learning derives its advantages from two main characteristics of mobile devices which are portability and connectivity (Bachore, 2018).

Portability makes learners to move with the devices to various places due to size and weight. Connectivity on the other hand refers to the possibility of handheld mobile devices to be connected to other devices, or a common network by creating a shared network. With the availability of electronic technologies, learners can access a multitude of information online and use them to explore their potentials. Ezugwu and Ezeudu (2022) stated that the use of handheld mobile devices in the process of teaching and learning improves the relationship between teachers and learners, promoting their interaction which will lead to a more active learning, and influence their study habits. In the same vein, Okoroafor (2022) opined that mobile learning as a form of learning is on the increase, as education has outgrown the physical constraints of the

classrooms. It improves students' study habits and gives them liberty to have almost limitless access to the content of any subject area as information are handy on the internet.

Many handheld mobile devices were developed specifically for learning purposes, for example e-readers. Moreover, many learning/educational applications (software) have been developed to run on mobile devices. They include google meet, zoom, whatsapp, google scholar among others (Mgboro et al., 2024). Software leverage on the portability and connectivity of regular handheld mobile devices. However, some of the devices that are appropriate for specific learning tasks are too expensive for most of the learners in secondary schools. There are other limitations such as small screen size, limited presentation of graphics, dependence on network that may not be readily available when needed, distractions from other applications on the same device such as social media, music, movies, games and so on. In fact, due to the aforementioned advantages and disadvantages of handheld mobile devices to secondary school learners, there has been debate on whether learners in secondary schools should be allowed to use smart phones and the likes in school and at home. It is very important to note that Artificial Intelligence (AI) application is now installed in many handheld mobile devices. Teachers and learners now use it to simplify the process of teaching and learning.

Artificial Intelligence (AI), once seen as a futuristic concept, has become a practical and transformative tool in many sectors, including education. In the process of teaching and learning, Artificial Intelligence (AI) is being increasingly employed to personalise learning, provide immediate feedback, support differentiated instruction, and boost students' engagement and achievement through interactive platforms. It serves as an intelligent tutor, offering real time assistance, answering student queries, and guiding learners through problem solving processes. It also promotes individualised learning, helping students understand abstract concepts at their own pace. According to Kaplan and Haenlein (2019), Artificial Intelligence (AI) mimics human intelligence by learning, reasoning, and making decisions. Similarly, Luckin (2021) and UNESCO (2022) affirm that Artificial Intelligence (AI) in teaching, enhances students' study habits, comprehension and provides teachers with insights into learners' progress and challenges. As noted by Luckin (2021), AI technologies can analyse learners' responses, detect misconceptions, and adjust lesson paths to suit individual needs—something human teachers might struggle to accomplish with large class sizes. In the global context, AI-driven tools such as Carnegie Learning's "MATHia" and IBM's "Watson Tutor" have demonstrated measurable improvements in students' performance (Holmes and Bialik, 2020). In Nigeria, studies such as that done by Ajibade (2022) show that AI-based instructional supports can reduce students' anxiety, improve their study habits and improve conceptual understanding, particularly in urban secondary schools with basic digital infrastructure.

Artificial Intelligence (AI) affects learners at all levels of education including secondary school level, and all subjects including Biology (Okoli and Emenike, 2023).

Biology is a popular subject among science students. It is a natural science subject consisting of contents from microscopic organisms to the biosphere in general, encompassing the earth's surface and all living organisms (Ibrahim et al., 2018). Similarly, Kyado et al. (2019) defined Biology as the study of plants and animals and their interactions with their physical environment. Biology can be said to be the study of plants and animals, and how they relate with their environment. Biology is an important subject as it provides the basis for important fields in the society such as pharmacy, nursing, medicine, agriculture and so on. Successful teaching and learning of any subject could be influenced by factors that come from within learners and those from without (Popoola et al., 2021). Factors from within include psychological and physiological factors, while factors from without are environmental and instrumental factors. Among the psychological factors is study habit.

Study habit is the combination of both the classroom learning and out of classroom learning (Sakirudeen and Sanni, 2017). Adinna and Anene (2024) defined study habit as learner's repeated actions to study from the beginning to the end of all educational programmes. Study habit could be said to be the degree to which the student engages in regular acts of learning characterised by appropriate learning routines. Furthermore, Adinna and Anene (2024) posited that study habits that could lead to higher academic performance include visiting library, note taking, appropriate use of internet, reading books and attending classes. These activities can enhance Biology students' study habits which could improve academic performance.

There has been argument among parents, teachers, learners, and other education stakeholders on the use of handheld mobile devices both in school and at home by secondary school students. While some are of the view that secondary school students be allowed to use mobile phones as it will help them have access to information and education applications, others disagree with the view stating that it will distract the learners and introduce them to the ills of social media. More so, Okore et al. (2023) investigated on the influence of mobile phone services on students' study habits in Nigeria. The study showed that chatting on facebook, online sport betting, downloading and playing music, whatsapp chatting, e-mail services are among the mobile phone internet services used by the students. The study found that using these mobile phone services during private study and lesson periods negatively affect study habits. Biswajit and Biswajit (2024) carried out a study on the impact of handheld mobile devices on the study habits of students in Raiganj University, West Bengal, India. The study found that 88.64% agreed that mobile technology has improved their study habits. A research was conducted by Esan et al. (2025) on the impact of smart phones use on learning effectiveness: A case study of college students in Nigeria. It was found that majority of the respondents spent more than five hours on their mobile phones daily. About 57% of the respondents had poor pattern of mobile phone usage, and 59% had bad study habits. There were significant relationships between mobile phone use and study habits. This study therefore sought to find out how handheld mobile devices

and Artificial Intelligence (AI) predict the study habits of secondary school Biology students in Abia State, Nigeria.

Literature Review

In this section, the related literature was reviewed based on the variables in this study.

- **Handheld Mobile Device Learning**

Handheld Mobile Device is one of the Information and Communication Technology (ICT) tools used in various fields of human endeavour including education. The learning process supported by handheld mobile devices is known as Handheld Mobile Device Learning (Ezugwu and Ezeudu, 2022). Bachore (2018) defined handheld mobile device learning as the process of learning which includes any kind of handheld mobile device such as cell phones, Personal Digital Assistants (PDAs), smart phones, pads, pods etc. Handheld Mobile Device Learning can also be seen as the use of technologies in learning particularly where device portability gives specific merits (Kukulska-Hulme, 2023). Spifonova and Ronchetti (2016) see it as a computational device that is small, self-directed and unnoticeable for every day's use. Furthermore, a description of what defines a device to be mobile is that it is wearable (De Frietas and Levene, 2018). By being wearable, it becomes part of a person's daily wardrobe, filling a need as important as a piece of clothing, fitting into a pocket or purse, and very likely being kept with the person everytime (Livingstone, 2019). The discussion on handheld mobile device in this study does not include laptop computers since they do not fit into the category of being wearable; although they are portable, they are not currently mobile in the sense of being wearable.

- **Benefits of Handheld Mobile Device Learning**

The importance of handheld mobile device learning across institutions of learning must not be ignored. The process of teaching and learning has now become innovative because of smartphones and other devices in promoting and advancing 21st century skills and knowledge (Emerson and Berge, 2018). Learners have experiences of digital surroundings through the use of mobile devices such as tablets and smart phones. Mokoena (2022) posits that learners' engagement in the use of smart phones improves collaborative learning through its connection to the internet. This implies that the use of handheld mobile devices makes learners to be more engaged in learner centred participatory learning. This is a clear indication on numerous supports that handheld mobile devices have made learners to advance in their understanding by increasing academic performance, social media participation and information sharing, which helps their social skills.

Furthermore, Mokoena (2022) continued that group projects and/or work given to learners by their teachers are simply and comfortably carried out through the use of handheld mobile devices. The challenge of communication in classrooms with learners is solved with the use of smartphones. This is because learners are now able to record their teachers' lessons in real time. With the advent of handheld mobile devices, what the learners do outside the classroom is

very much similar to what they do inside the classroom. This is possible because many lesson applications can be used to listen and learn from a tutor just as one listens to the teacher.

In another submission, Adomi et al. (2024) stated that handheld mobile devices when used for the purpose of learning improves learners' engagement in learning by surfing the web for information to solve individual and group assignments, communicating through e-mail, connecting with peers and friends, and for entertainment. The authors continued that these technologies help secondary school learners to communicate with one another, to be able to search for educational information that will help them in their school tasks and be able to know what is happening around the world. The introduction and use of mobile devices can help learning and make education more entertaining for secondary school students. In fact, many schools in Abia State, Nigeria have started using handheld mobile gadgets to promote education, keep students up to date with assignments, and offer help to those in need (Boyd and Ellison, 2007). Despite all the benefits of handheld mobile devices among secondary school learners, many arguments can still be made about the possible challenges associated with it.

- **Challenges of Handheld Mobile Device Learning**

Many learners are able to carry out tasks through handheld mobile device in both the classroom and at home, while others experience some level of distraction. The mere visibility and presence of handheld mobile devices attract the attention of students in school or even adults at home. Many learners can be shifting their focus between the handheld mobile devices as a medium of entertainment, and at the same time, a learning device (Barnwell, 2016). The use of handheld mobile device for learning means that learners have to combine information and at the same time stay focused on their lesson in the class. For learners who have low literacy skills and the steady urge to multitask on social media, blending the purposeful use of smart phones into classroom activities can be particularly challenging. Then, the objective of the device (which is learning) tends to be forgotten (Ifeanyi and Chukwuere, 2018). Young learners who are still within the level of adolescents use handheld mobile devices to invite and initiate social circles where friendships are initiated. Friendships that are initiated over social media tend to be more recreational and are less based on educational purposes, especially when such relationships are among adolescents (Ifeanyi and Chukwuere, 2018). The implication of the above sentence is that, it is a clear indication that less attention is given by learners to their academic work and activities in the presence of handheld mobile devices. Some schools have banned the use of smart phones and other mobile devices in classes or during lessons; the reason being that it aids cheating during their tests and examinations (Buck et al., 2023).

The easy access to internet on the handheld mobile devices helps the learners to simply find answers to their test or examination questions online, thereby enabling the learners to pass their examination, but not helping them to have real knowledge about what they are being taught by their teachers. Odofin (2024) opined that handheld mobile devices through the use of the

internet on them has disconnected children from their parents, peers and academic activities, making it impossible to acquire social skills, communication skills, emotional skills, and basic problem solving skills, which may have adverse effect on the child's morale, attitude, psychological well-being, habits and learning behaviour, because so much time and attention could be wasted by the child on engaging in internet. The author summarised some adverse effects of handheld mobile devices usage among learners to include source of distraction to the child, disengaging the child from social interaction, aids examination malpractice, sleep deprivation, risky sexual behaviours, aggressive behaviours, social and psychological problems, unreliable sources of information online among others. Furthermore, young people who are mostly secondary school students pay great attention to their internet-enabled phones, also to what their peers think of them. The use of handheld mobile devices does not only cause mental effects, but there also exist other impacts caused by the continuous use of such devices, which has been identified as addiction.

Recently, psychologists have issued cautions that cell phone users face the risk of being addicted to their phones. There have also been some medical concerns that have been raised in connection with the use of smart phones. Such concerns include insomnia, anxiety, misery and others (Ezemenaka, 2023). Furthermore, Arike et al. (2013) posited that educational technology and media are still not sufficiently applied in secondary schools because of reasons such as lack of equipment, necessary resources, and lack of technical knowledge of teachers for the implementation of new technologies. For these reasons, the researchers suggested that mobile learning could stand in the gap. From the foregoing, the benefits and challenges of mobile electronic technology learning linger the argument of whether learners in secondary schools should be allowed to engage in handheld mobile learning both in school and at home or not.

- **Artificial Intelligence (AI) in Education**

Artificial Intelligence has revolutionised instructional delivery by enabling adaptive learning, personalised feedback, and automated tutoring systems. As noted by Luckin (2021), AI technologies can analyse learners' responses, detect misconceptions, and adjust lesson paths to suit individual needs—something human teachers might struggle to accomplish with large class sizes. In the global context, AI-driven tools such as Carnegie Learning's "MATHia" and IBM's "Watson Tutor" have demonstrated measurable improvements in student performance (Holmes and Bialik, 2020). In Nigeria, studies such as that by Ajibade (2022) show that AI-based instructional supports can reduce students' anxiety toward Mathematics and improve conceptual understanding, particularly in urban secondary schools with basic digital infrastructure.

- **Artificial Intelligence Chatbots in Education**

Artificial Intelligence chatbots are one of the most practical applications of AI in teaching and learning. These conversational agents simulate human dialogue and provide instant explanations, reminders, and personalised support. Chua and Annamalai (2025) explain that AI

chatbots act as virtual tutors capable of engaging students through natural language interaction, encouraging self-paced learning and confidence building. Similarly, Labadze et al. (2023) highlight that AI chatbots have enhanced formative assessment by providing immediate feedback, though they caution that excessive dependence may reduce critical thinking if not supervised by teachers.

In Nigeria, the use of AI chatbots is gradually gaining ground. Eze and Olawale (2024) found that students exposed to chatbot-based Mathematics lessons demonstrated better retention of algebraic concepts compared to those taught through traditional lectures. The researchers attributed this to the interactive question-answer format that maintains students' attention and curiosity. This shows that chatbot integration can bridge the feedback gap in resource-constrained classrooms. This research also sought to investigate the predictive potency of Handheld Mobile Devices and Artificial Intelligence on secondary school Biology students' study habits.

▪ Study Habits

Different people have different ways and methods to study at any level of education. Study habits according to Jafari et al. (2019) refer to different individual behaviours related to learning, and how methods and skills are put together during studying. In another submission, Okoli and Emenike (2023) stated that study habits consist of behaviours and skills that can improve motivation and convert learning in an effective process with high returns, which ultimately improves learning. Furthermore, Mendezabal (2023) posited that study habits refer to the pattern of behaviours exhibited by learners in the pursuit of their studies that serve the drive for learning. The author continued that study habits comprise the degree to which the learner engages in regular acts of learning that are characterised by appropriate study routines. Study habits can therefore be seen as the aggregate of all behaviours adopted in the process of studying.

Jafari et al. (2019) opined that study habits can be categorised as good or bad. Good study habits include studying daily, studying in a quiet environment, keeping good notes, being organised, reading text books and other materials, attending classes, listening to the teacher in the class, turning off TV, phones and other devices that could interfere with studies, solving and submitting assignments, writing tests and examinations, participating in practical sessions, asking questions where necessary etc. Bad habits could be procrastination, skipping classes, noise making in the class, not doing assignments, not writing tests and examinations, not participating in practical sessions, watching television or playing games instead of studying, not keeping notes, reading in an inappropriate environment, and so on. Handheld Mobile Devices and AI can influence learners' study habits. There are previous studies that are related to handheld mobile devices and study habits. Biswajit and Biswajit (2024) carried out a study on the impact of handheld mobile devices on the study habits of PG students in Raiganj University, West Bengal, India. It was found that 88.64% of the students agreed that handheld mobile

devices have improved their study habits. On the other hand, Okore et al. (2023) investigated on the influence of mobile phone services on students' study habits in tertiary institutions in Nigeria. The study found that using these mobile phone services during private study and lecture periods negatively affect study habits. These differences in the findings of previous researchers necessitated the present study. To further buttress the necessity of this research, Technology Acceptance Model, and Constructivist theory were reviewed.

- Technology Acceptance Model (TAM)

The Technology Acceptance Model is an information system theory propounded by Fred Davis in 1989. The theory explains how users form attitudes and intentions to use technology, leading to actual adoption and usage. The model debunked the idea that people hurriedly embrace new technologies such as handheld mobile devices rather, opined that when users are presented with a new technology, dual constructs influence their decision about how and when they will use it. The two constructs are Perceived Usefulness (PU) and Perceived Ease of Use (PEU).

Perceived Usefulness is the degree to which a person believes that using a particular technology will improve their performance or achieve a specific goal, while Perceived Ease of Use is the degree to which a person believes that using a particular technology will be free from effort. Technology Acceptance Model has been widely applied in various fields including information and communication technology to predict and explain technology adoption behaviours, including when and how to use technology of any kind for the optimum benefit of the users.

Technology Acceptance Model has strong behavioural inclination. It presupposes that when someone forms an intention to act, they will be free to act without limitations. In the real sense, there will be many constraints to act out the intent. Because technologies such as handheld mobile devices are complex and there exists elements of uncertainty on whether secondary school students have good intentions of using handheld mobile devices, study habits of the students may be affected. Technology Acceptance Model explains the perceived usefulness and usage intentions in terms of social influence and cognitive instructional processes of the technology. The purpose of this model is to predict the acceptability of a tool and to identify the modifications which must be brought to the system in order to make it acceptable to users. This model postulated that the use of an information system is determined by the behavioural intentions, but on the other hand, the behavioural intentions are determined by the person's attitudes towards the use of the system, and also by his perception of its utility. According to the proponent, the attitude of an individual is not the only factor that determines his use of a system, but is also based on the impact which it may have on the performance.

The model is used in this study because it explains technology adoption behaviours, including when and how to use technology of any kind for the optimum benefits of the user. Technology usage can influence learners' attitudes and study habits.

- Constructivist Learning Theory (CLT)

Constructivist Learning Theory was introduced by Jean Piaget in 1936. The theory states that human knowledge is innate and learning is attained through 'construction' of knowledge. It explains how children construct knowledge and understanding through active learning and experience. By implication, the learner is not just to be fed with information all the time but should be given the opportunity to organise his/her schemas to develop knowledge. Piaget continued that constructivist theory has three basic components; schemas, adaptation process, and stages of cognitive development. Schemas, according to Piaget are the building blocks of knowledge. The learner already has an existing knowledge and it is directly shaped by experience.

Piaget stated that adaptation process comprises of assimilation, accommodation, and equilibration. Assimilation refers to using an existing schema to deal with a new object or situation. Accommodation happens when the existing schema (knowledge) needs to be changed to deal with a new object or situation, and equilibration is the force that moves development along. Assimilation and accommodation require an active learner, not a passive one, because problem solving skills cannot be taught, they must be discovered. The foregoing points to the fact that handheld mobile devices can make learners to discover new knowledge and information by themselves. Similarly, AI can enable the learners to have confidence in themselves that they can explore and discover new knowledge and facts by themselves, as stated in this theory.

The last component of Piaget (1936) constructivist theory involves four stages of cognitive development. The stages include:

- Sensory motor stage (birth to age 2)

- Preoperational stage (age 2 to age 7)

- Concrete operational stage (age 7 to age 11)

- Formal operational stage (age 11 and above)

This study is related to the fourth stage as secondary school students belong to this category. At this stage (formal operational stage), people develop the ability to think about abstract concepts and logically test hypotheses. Piaget continued that within the classroom, learning should be student centred and accomplished through active discovery learning. The role of the teacher is to facilitate learning, rather than dominating the process. Therefore, teachers should encourage the following:

- Focus on the process of learning, rather than the end product.

- Allow learners to study on their own, with the confidence to rediscover and reconstruct 'truths'.
- Devising situations that present useful problems, that learners will find solution either individually or collaboratively.
- Evaluate the level of the child's development so that suitable tasks can be set.

This study therefore, may help to address the requirements suggested by Piaget because handheld mobile devices can make the learner active in the teaching and learning process at home or in school. By implication, Biology teachers in secondary school should be able to evoke and challenge the confidence level and the reasoning ability of the learner to enhance cognitive growth and advance the thinking ability of the child. Keeping the learners engaged in activities like handheld mobile devices may provide the opportunity for social interaction and cognitive learning which are characteristics of formal operational stage. The reports of some previous researchers were also reviewed.

Biswajit and Biswajit (2024) carried out a study on the impact of mobile technology on the study habits of PG students in Raiganj University, West Bengal, India. A descriptive survey design was used for the study. One hundred PG students constituted the population of the study, and census sampling technique was used as the whole population could be handled. Structured questionnaire was used as the instrument for data collection. Regression and ANOVA were adopted for data analysis. The study found that 88.64% agreed that handheld mobile devices have improved their study habits.

Okore et al. (2023) investigated on the influence of handheld mobile phone services on students' study habits in tertiary institutions in Nigeria. A descriptive survey design was used for the study. Questionnaire was adopted as the instrument for data collection from 448 respondents from six institutions offering Library and information Science in South-South and South-East, Nigeria. Simple random sampling technique was used to draw the sample of 448 respondents. Regression was used to test the hypotheses for the study. The study showed that chatting on facebook, online sport betting, downloading and playing music, whatsapp chatting, e-mail services are among the mobile phone internet services used by the students of tertiary institutions. The study found that using these mobile phone services during private study and lecture periods negatively affect study habits. It was concluded that if the use of handheld mobile phone services are not controlled, students may continue to have poor academic performance.

A research was conducted by Esan et al. (2025) on the impact of smart phones use on learning effectiveness: A case study of college students in Nigeria. The design of the study was a quantitative descriptive cross-sectional study. A sample of 382 students across various colleges and class levels in a private university in Nigeria were chosen using multi stage sampling technique. Data were obtained using a semi structured pretested questionnaire. Analysis of Variance (ANOVA) was used for data analysis. It was found that majority of the respondents

spent more than five hours on their mobile phones daily. About 57% of the respondents had poor pattern of handheld mobile phone usage, and 59% had bad study habits. There were significant relationships between handheld mobile devices and study habits.

The previous studies show different outcomes of the relationship between handheld mobile devices and study habits. These differences also necessitate this present research.

Research Questions

The following research questions were posed for the study.

- i. To what extent does Secondary School Students' use of handheld mobile devices predict their study habits in Biology?
- ii. To what extent does secondary school students' use of artificial intelligence predict their study habits in Biology?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance

- i. Ho1: Handheld mobile devices do not significantly predict Secondary School Students' study habits in Biology
- ii. Ho2: Artificial intelligence does not significantly predict Secondary School Biology Students' study habits

Methodology

This study adopted correlational research design. Correlational studies indicate the direction and magnitude of the relationship between variables, and is determined through the use of correlation coefficients. The population of this study was 13,947 senior secondary three (SS III) students in public secondary schools in Abia State, Nigeria in 2025/2026 academic session (Nigeria Digest of Education Statistics, 2025). The choice of SS III students was because the students in this class have passed through two years of teaching in Biology (SSI and SSII), which gives them more experience than other classes. A sample size of 386 SS III Secondary School Biology students were used for the study. The sample size was determined using Taro Yamane formula for sample size in survey research. Simple random sampling technique was employed to draw the sample. Simple random sampling by balloting was used to draw one education zone from the state. Thus, Umahia education zone was drawn. Simple random sampling was again used to draw two Local Government Areas that constituted Umuahia Education zone. Umuahia North and Ikwuano Local Government Areas were sampled. Simple random sampling technique was then employed to sample two schools from each Local Government Area. The schools sampled were Ibeku High School, Umuahia and Isieke Community Secondary School for Umuahia North Local Government Area, and Ikwuano Secondary School, Ariam and Awom Naebo Secondary School, Amawom for Ikwuano Local Government area. The instruments used for data collection in this study include Handheld Mobile Devices Questionnaire (HHMDQ),

Artificial Intelligence Questionnaire (AIQ), and Students' Study Habits Questionnaire (SSHQ). The instruments were divided into two sections. Section A sought information on personal data which include name of school and class of the respondents, while section B sought information about the respondents' opinions on the item statements. They were all adapted from DeVellis (2017). Each instrument contains 20 items with a modified 4-point Likert rating scale. The scoring for positively cued items was strongly Agree (4), Agree (3), Disagree (2) and Strongly Disagree (1). The scoring for negatively cued items was Strongly Agree (1), Agree (2), Disagree (3), Strongly Disagree (4). The instruments for this study were validated by three experts. Two experts in Biology Education and one in Measurement and Evaluation units of the Department of Science Education, Michael Okpara University of Agriculture, Umudike. The copies of the instruments after validation were administered to 20 SS III Biology students of Government College, Umuahia, Abia State, to determine their reliability. The data obtained were subjected to reliability tests using Cronbach's Alpha formula. Reliability indices of 0.83, 0.70, and 0.89 were obtained for Handheld Mobile Devices Questionnaire (HHMDQ), Artificial Intelligence Questionnaire (AIQ), and Students' Study Habits Questionnaire (SSHQ) respectively. The adoption of Cronbach's Alpha was because the items were polytomously scored, consisting of Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). Research assistants (SS III Biology teachers) in all the sampled schools were used to administer the instruments to the respondents. This was done after obtaining permission from the school authorities to conduct research using their students as respondents. The research assistants were in charge of the administration of the instruments to the students and collation of filled instruments from them and handed over to the researcher. Data were recorded after the collation of all instruments. Only filled and returned instruments were used for data analysis. Pearson Product Moment Correlation was used to answer the research questions, while Simple Regression was used to test the null hypotheses at 0.05 level of significance. Pearson Product Moment Correlation and Regression were considered appropriate because the study intended to determine the extent of relationship and predictive potency of the variables respectively. The extent of the relationship between the variables was interpreted using the Nworgu (2015) correlation coefficient scale:

- 0.00 = No relationship
- 0.01–0.19 = Very low relationship
- 20 – 0.39 = Low relationship
- 40 – 0.59 = Moderate relationship
- 60 – 0.79 = High relationship
- 80 – 0.99 = Very high relationship
- 1 = Perfect relationship

Furthermore, any p-value that is equal to or greater than 0.05 is not significant and therefore, the null hypothesis was not rejected. Any p-value that is less than 0.05 is significant and therefore, the null hypothesis was rejected.

Results and Findings

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

▪ Research Question 1

To what extent does Secondary School Students' use of handheld mobile devices predict their study habits in Biology?

Table 1

Pearson Product-Moment Correlation Analysis of the Extent to Which Secondary School Students' Use of Handheld Mobile Devices Predicts Their Study Habits in Biology

Variable		Handheld Mobile Devices	Study Habits
Handheld Mobile Devices	Pearson correlation	1	.698**
	Sig. (2-tailed)		.000
	N	386	386
Study Habits	Pearson correlation	.698**	1
	Sig. (2-tailed)	.000	
	N	386	386

Note. ** Correlation is significant at the .05 level (two-tailed).

Result in Table 1 is correlation coefficient of extent to which Secondary School Students' use of handheld mobile devices predict their study habits. Results showed a correlation coefficient (r) of .698 which is a positive correlation and is within the coefficient limit of +/- 0.60–0.79 as high extent relationship. This indicates that secondary School Students' use of handheld mobile devices positively relates to their study habits to a high extent.

A corresponding hypothesis formulated to further address the research question is hypothesis 1.

▪ Hypothesis 1

Handheld mobile devices do not significantly predict Secondary School Students' study habits in Biology

Table 2

Regression Analysis of the Predictive Potency of Handheld Mobile Devices on Secondary School Biology Students' Study Habits

Model	Sum of Squares	Df	Mean Square	F	Sig.
1 Regression	36,829.169	1	36,829.169	189.706	.000
Residual	38,827.668	384	194.138		

Model	Sum of Squares	Df	Mean Square	F	Sig.
Total	75,656.837	385			
R ²		.487			

Note. Dependent variable: Study Habits. Predictor: (Constant), Handheld Devices. df = degrees of freedom; F = calculated F value; correlation is significant at the .05 level (two-tailed).

Table 2 revealed the F-calculated value of 189.706 at 0.05 level of significance. The table also shows that the P-value of .000 is less than the alpha value at 0.05; the null hypothesis, which states that handheld mobile devices do not significantly predict secondary school Biology students' study habits, is therefore rejected. This implies that Secondary School Students' use of handheld mobile devices significantly and positively predict their study habits in Biology to a high extent. The coefficient of determination ($R^2 = 0.487$) shows that 48.7% of the variation in students' study habits is explained by their use of handheld mobile devices, while the remaining 51.3% is influenced by other factors not examined in this study.

▪ Research Question 2

To what extent does secondary school students' use of artificial intelligence predict their study habits in Biology?

Table 3

Pearson Product-Moment Correlation Analysis of the Extent to Which Secondary School Biology Students' Use of Artificial Intelligence Predicts Their Study Habits

Variable		Artificial Intelligence	Study Habits
Artificial Intelligence	Pearson correlation	1	.759**
	Sig. (2-tailed)		.000
	N	386	386
Study Habits	Pearson correlation	.759**	1
	Sig. (2-tailed)	.000	
	N	386	386

Note. ** Correlation is significant at the .05 level (two-tailed).

Result in Table 3 is correlation coefficient of extent to which Secondary School Biology Students' use of AI predicts their study habits. Results showed a correlation coefficient (r) of .759 which is a positive correlation and is within the coefficient limit of +/- 0.60–0.79 as high extent relationship. This indicates that secondary School Biology Students' use of AI positively relates to their study habits to a high extent.

A corresponding hypothesis formulated to further address the research question is hypothesis 2.

▪ Hypothesis 2

Artificial intelligence does not significantly predict Secondary School Biology Students' study habits

Table 4

Regression Analysis of the Extent to Which Artificial Intelligence Predicts Secondary School Biology Students' Study Habits

Model	Sum of Squares	Df	Mean Square	F	Sig.
1 Regression	43,587.919	1	43,587.919	271.839	.000
Residual	32,068.917	384	160.345		
Total	75,656.837	385			
R ²		.576			

Note. Dependent variable: Study Habits. Predictor: (Constant), Artificial Intelligence. df = degrees of freedom; F = calculated F value; correlation is significant at the .05 level (two-tailed).

Table 4 revealed the F-calculated value of 271.839 at 0.05 level of significance. The table also shows that the P-value of .000 is less than the alpha value at 0.05; the null hypothesis, which states that the use of artificial intelligence does not predict secondary school Biology students' study habits, is therefore rejected. This implies that Secondary School Biology Students' use of Artificial Intelligence significantly and positively predicts their study habits in Biology to a high extent. The coefficient of determination ($R^2 = 0.576$) shows that 57.6% of the variation in students' study habits is explained by their use of AI, while the remaining 42.4% is influenced by other factors not examined in this study.

Discussion

Based on the results above, it was found that Secondary School Students' use of handheld mobile devices significantly and positively predicts their study habits in Biology to a high extent. This shows that parents and teachers alike have to focus on the use of handheld mobile devices and AI usage by students both in school and at home. If well implemented and controlled, handheld mobile devices and AI can improve learners' study habits. Good study habits could bring about better performance among students in Biology. This finding is in agreement with the findings of Ezugwu and Ezeudu (2022) who stated that the use of handheld mobile devices in the process of teaching and learning improves the relationship between teachers and learners, promoting their interaction which will lead to a more active learning, and influence their study habits. In the same vein, Okoroafor (2022) opined that mobile learning as a form of learning is on the increase, as education has outgrown the physical constraints of the classrooms. It improves students' study habits and gives them liberty to have almost limitless access to the content of any subject area as information are handy on the internet.

The implication here is that learners may find it easier to watch educational videos, read downloaded materials, surf the internet etc using their mobile devices anytime and anywhere than reading their notes and hard copies of their textbooks.

By contrast, the findings of the present study do not align with the findings of Okore et al. (2023) which stated that chatting on facebook, online sport betting, downloading and playing music, WhatsApp chatting, e-mail services are among the mobile services used by students during private time and even during lecture periods, and they negatively affect their study habits. The reason for the discrepancy between the present and the reviewed studies could be because of different levels of students used in both studies and the designs adopted. The reviewed study adopted descriptive research design using students in tertiary institutions, while the present study adopted correlation design using students in secondary schools.

Furthermore, the results of the study also show that Secondary School Biology Students' use of Artificial Intelligence significantly and positively determines their study habits in Biology to a high extent. This finding agrees with the findings of Luckin (2021) and UNESCO (2022) which affirm that Artificial Intelligence (AI) in teaching, enhances students' study habits, comprehension and provides teachers with insights into learners' progress and challenges. Similarly, Ajibade (2022) show that AI-based instructional supports can reduce students' anxiety, improve their study habits and improve conceptual understanding. This implies that the use of artificial intelligence presents an individual with the abilities to carry out academic tasks such as assignment, class work, practicals, class exercise among others. Effective completion of these tasks signifies that an individual has good study habits.

Limitations

1. Since the study covers Abia State only, the results may not generalize to other states in Nigeria with different infrastructure, culture, and curriculum implementation.
2. Not all students own smartphones or tablets. Some share devices with siblings or parents. These impede frequent use of the devices by the students.

Conclusion

This study investigated handheld mobile devices and artificial intelligence as predictors of Secondary School Biology students' study habits in Abia State, Nigeria. Based on the findings of the study, it could be concluded that handheld mobile devices and artificial intelligence significantly to a high extent relate to students' study habits in Biology. Thus, parents, guardians and teachers should ensure that they control the use of handheld mobile devices and other electronic gadgets among secondary school students so that the aim will not be defeated.

Recommendations

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

Government and school administrators should give guidelines on the use of handheld mobile devices and artificial intelligence among secondary school students in order to bring

about good study habits since it was found that handheld mobile devices and artificial intelligence significantly and positively determines study habits to a high extent.

School administrators should have Information and Communication Technology (ICT) units in their schools in order to train students on the use of handheld mobile devices and artificial intelligence.

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Effects of AI-Driven Real-Time Captioning as an Orthographic Scaffold for Literacy Acquisition Among Deaf Learners in Plateau State, Nigeria

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Abstract

The literacy gap between deaf and hard-of-hearing (DHH) learners and hearing peers remains crucial in resource-constrained settings like Plateau State, Nigeria. Although human sign language interpretation gives conceptual access, DHH learners sometimes fail to develop direct orthographic representations of difficult English vocabulary due to fast fingerspelling and visual fatigue. This study examined AI-driven real-time captioning as a collaborative orthographic scaffold alongside human sign language interpreters. Using a quantitative quasi-experimental pretest-posttest control group design with delayed retention, 30 Primary Five pupils at Plateau State School for the Deaf, Bassa, were cluster-randomised into two intact groups: Experimental (AI captioning + sign interpretation; n=15) and Control (sign interpretation only; n=15). The eight-week intervention includes pretest, immediate posttest, and four-week delayed retention evaluation. Data were obtained using a validated 40-item English Literacy and Vocabulary Assessment (ELVA) and evaluated with independent-samples t-tests and ANCOVA. The Experimental Group attained considerably better posttest scores ($M=74.20$, $SD=6.85$) than the Control Group ($M=58.40$, $SD=7.92$), $t(28)=5.84$, $p<0.001$, Cohen's $d=2.13$. ANCOVA confirmed a substantial intervention effect, $F(1,27)=38.65$, $p<0.001$, partial $\eta^2=0.589$, adjusting for pretest scores. Delayed retention was likewise considerably higher for the Experimental Group ($M=71.80$, $SD=7.10$) than the Control Group ($M=52.60$, $SD=8.15$), $t(28)\approx 6.88$, $p<0.001$, Cohen's $d\approx 2.51$. Technical evaluation recorded an average Word Error Rate of 8.4% employing edge-computing hardware and FM lapel mics, circumventing internet instability. Findings imply simultaneous visual-verbal captioning and visual-nonverbal signing increase orthographic-lexical mapping without replacing sign language. Recommendations address policy, edge-hardware adoption, and teacher ICT competence training in Nigerian special schools.

Keywords: Deaf Education; AI Real-Time Captioning; Orthographic Scaffolding; Literacy Acquisition; Quasi-Experimental Study; Nigerian Special Education

Introduction

The acquisition of functional literacy is a foundational prerequisite for academic achievement, economic self-sufficiency, and social inclusion. However, a profound and persistent literacy gap exists globally between deaf and hard-of-hearing (DHH) learners and their hearing peers (Marschark and Knoors, 2020). In developing nations such as Nigeria, this disparity is particularly acute due to systemic resource constraints, limited access to specialised instructional technology, and broader socio-economic challenges in special education infrastructure (Ademokoya, 2021).

For hearing children, reading development relies heavily on an auditory-phonological loop through which printed orthographic symbols map onto pre-established spoken-language sounds encountered through years of direct acoustic exposure. Conversely, DHH pupils, such as those attending the Plateau State School for the Deaf, Bassa, interact with written English as an essentially visual-graphic system disconnected from spoken phonology. Consequently, DHH learners must construct direct visual-orthographic mappings to semantic meaning, a cognitive process requiring intensive, explicit, and sustained visual print exposure paired with clear contextual definitions (Marschark and Knoors, 2020).

In Nigerian special schools, instruction for DHH pupils is primarily facilitated through human sign language interpreters utilising Nigerian Sign Language (NSL) or Signed Exact English (SEE). While human interpretation provides indispensable access to conceptual knowledge, it may present challenges when introducing specialised, low-frequency, or abstract English vocabulary. When presenting new technical terms, interpreters may rely on fingerspelling chains, spelling words letter-by-letter through dynamic hand shapes, or conceptual approximations. Rapid fingerspelling requires pupils to visually decode letters in fluid motion and may increase visual-attentional demands (Meade, 2022).

Advances in Artificial Intelligence (AI) and Automatic Speech Recognition (ASR) present novel opportunities to bridge this orthographic gap. When real-time AI-generated captions are streamed simultaneously alongside live sign language interpretation, DHH learners receive dual-modal visual input: visual-nonverbal signing for conceptual understanding and visual-verbal text for precise orthographic representation (Yoon and Kim, 2021). Rather than replacing human sign language interpreters, AI captioning can function as a collaborative orthographic scaffold, providing an instantaneous visual representation of academic vocabulary.

Despite its theoretical potential, empirical research investigating the practical efficacy of AI captioning in Sub-Saharan African special education classrooms remains limited. Existing literature on speech-to-text technology predominantly originates from high-resource contexts featuring standardised accents, relatively controlled acoustic environments, and reliable digital infrastructure. These conditions differ substantially from Nigerian classrooms, where local accent variations, ambient noise, power interruptions, and unstable internet connectivity may

affect technological deployment. Therefore, an empirical investigation examining both the literacy effects and technical feasibility of AI captioning in a Nigerian special-school setting is warranted.

Purpose of the Study

The primary purpose of this study was to empirically evaluate the effect of AI-driven real-time captioning, used as a collaborative orthographic scaffold alongside human sign language interpretation, on the English literacy and vocabulary acquisition of Primary Five pupils at the Plateau State School for the Deaf, Bassa, Nigeria.

Research Objectives

Specifically, the study sought to:

1. determine the difference in posttest English literacy and vocabulary scores between pupils exposed to AI real-time captioning with human sign language interpretation (Experimental Group) and those exposed to human sign language interpretation only (Control Group);
2. assess the effect of the AI captioning intervention on pupil retention of low-frequency academic vocabulary over time; and
3. evaluate the technical accuracy, measured by Word Error Rate (WER), of edge-based AI speech-recognition software operating in a typical Nigerian deaf classroom environment.

Research Hypotheses

The following null hypotheses were tested at the .05 level of significance:

H01: There is no statistically significant difference in posttest English literacy and vocabulary acquisition scores between Primary Five deaf pupils exposed to AI real-time captioning alongside human sign language interpretation and those exposed to human sign language interpretation alone, when controlling for pretest achievement.

H02: There is no statistically significant difference in delayed posttest vocabulary retention scores between the Experimental Group and the Control Group.

Literature Review

The disparity in literacy levels between deaf and hard-of-hearing (DHH) students and their hearing counterparts continues to be a significant worldwide issue, especially pronounced in resource-limited environments such as Nigeria (Ademokoya, 2021; Marschark and Knoors, 2020). DHH students are required to establish direct visual-orthographic connections to semantic meaning, given that written English functions as a visual-graphic system apart from spoken phonology (Marschark and Knoors, 2020). Although human sign language interpretation offers crucial conceptual understanding, swift fingerspelling for unknown terms may heighten visual-

attentional requirements (Meade, 2022). The advent of AI-generated captioning presents a prospective cooperative orthographic framework, delivering concurrent visual-verbal text in conjunction with visual-nonverbal signing (Paivio, 1991; Yoon and Kim, 2021).

Contemporary Nigerian research has commenced investigating the incorporation of AI in language instruction. Akinsulire et al. (2025) analyzed the application of AI technology in language education, whereas Aliyu et al. (2026) explored the impact of AI-assisted teaching on the academic performance of students with hearing disabilities. Olatunji and Olatunji-Olawepo (2025) evaluated the attitudes of AI sign language interpretation tools among Nigerian children with hearing disabilities and their educators. Olagoke and Adanlawo (2025) illustrated AI-based methodologies that improve vocabulary acquisition in multilingual educational settings. Moreover, Ubur (2026) investigated AI-enhanced emotional captioning to promote equitable STEM opportunities for DHH students, while Apata (2026) examined digital narratives and multimodal representations as innovative avenues in language advancement.

Theoretical grounds for this work synthesise Dual Coding Theory (Paivio, 1991), Cognitive Load Theory, and Universal Design for Learning. Paivio's model endorses concurrent visual-verbal and visual-nonverbal representations, but cognitive load factors indicate that consistent captions may alleviate the burdens linked to ephemeral fingerspelling. Stinson and Cawthon (2015) underlined curriculum accessibility for DHH learners, and Matthew (2020) highlighted caption accuracy as crucial to educational value of speech-to-text systems.

Despite theoretical promise, empirical research on AI captioning in Sub-Saharan African special education remains scarce. Existing material largely stems from high-resource environments with uniform accents and reliable infrastructure—conditions differing greatly from Nigerian classrooms (Yoon and Kim, 2021). Muhoozi (2025) and Madhu (2025) addressed AI-powered multilingualism and equity concerns, however localised evidence is scant. Milaham (2020) documented narrative storytelling practices for hearing-impaired pupils in Plateau State, offering regional context. Similoluwa et al. (2025) evaluated AI's involvement in managing handwriting and spelling issues among kids with learning challenges, suggesting broader applicability.

This work addresses the highlighted gap by empirically testing AI real-time captioning as an orthographic scaffold specifically inside Nigerian deaf education, examining both literacy effects and technological feasibility in actual classroom situations.

Theoretical Framework

This study was grounded in a synthesis of three complementary theoretical perspectives: Dual Coding Theory, Cognitive Load Theory, and Universal Design for Learning.

Dual Coding Theory

Paivio's Dual Coding Theory proposes that information can be processed through complementary cognitive systems involving verbal and non-verbal representations (Paivio, 1991). For deaf learners, simultaneous presentation of visual-nonverbal information through human sign language and visual-verbal information through printed AI captions provides complementary forms of representation.

In the present study, human sign language provided conceptual and linguistic information, while the AI-generated caption supplied a stable visual representation of the exact English orthography. The live text stream therefore functioned as a visual bridge connecting signed concepts with their written English forms (Paivio, 1991; Yoon and Kim, 2021).

Cognitive Load Theory

Cognitive Load Theory distinguishes among intrinsic load, extraneous load, and germane load. When DHH pupils attempt to decode rapid fingerspelling for unfamiliar academic vocabulary, the transient nature of the information may increase the demands placed on working memory. Real-time captions provide a relatively stable orthographic target that learners can visually reference while simultaneously attending to sign language.

The availability of a persistent textual representation may therefore reduce unnecessary cognitive demands associated with decoding transient fingerspelling and allow learners to devote greater cognitive resources to semantic processing and vocabulary development.

Universal Design for Learning

Universal Design for Learning advocates the provision of multiple means of representation, action and engagement to accommodate learner diversity. Integrating automated captioning establishes an additional means of representation through which DHH pupils can access instructional content. In this study, captioning complemented rather than replaced sign language interpretation, thereby supporting different levels of sign-language fluency, reading readiness and residual hearing.

Methodology

Research Design

The study adopted a quantitative quasi-experimental pretest-posttest control group design with a delayed posttest retention measure. A quasi-experimental design was considered appropriate because intact classroom settings were used to prevent ethical and administrative difficulties associated with disbanding established classes in a specialised school.

Participants were assigned through cluster randomisation at the level of intact instructional groups, rather than through individual random assignment. This distinction is important because the study retained the existing instructional structure of the school.

Research Design Layout

Table 1

Research Design Layout

Group	Pretest	Intervention	Immediate Posttest	Delayed Retention Test
Experimental Group (n = 15)	O ₁ (ELVA)	X ₁ (AI Captioning + Human Interpreter)	O ₂	O ₃
Control Group (n = 15)	O ₁ (ELVA)	X ₀ (Human Interpreter Only)	O ₂	O ₃

Participants and Setting

The target population comprised all Primary Five pupils enrolled at the Plateau State School for the Deaf, Bassa, Nigeria, during the 2025/2026 academic session. Primary Five was purposefully selected because it represents a crucial transitional academic stage in which pupils increasingly move from learning to read towards reading to learn in preparation for subsequent educational progression.

A total sample of thirty (N = 30) Primary Five DHH pupils participated in the study. The pupils were assigned through cluster randomisation into two intact instructional groups: Experimental Group (n = 15) and Control Group (n = 15).

Inclusion criteria required pupils to: (a) have severe-to-profound bilateral sensorineural hearing loss (≥ 71 dB HL); (b) rely on sign language as their primary classroom communication mode; and (c) have no co-occurring visual or intellectual disabilities.

Baseline Characteristics of Participants

Table 2

Baseline Demographic and Clinical Profile of Participants

Variable	Experimental Group (n = 15)	Control Group (n = 15)	Statistic / p-value
Age (Years, M $\pm$ SD)	11.87 $\pm$ 1.12	12.07 $\pm$ 1.03	t = 0.51, p = .614
Gender (Male / Female)	8 / 7	9 / 6	χ^2 = 0.13, p = .715
Hearing Loss Level (Severe / Profound)	4 / 11	5 / 10	χ^2 = 0.16, p = .691
Onset of Deafness (Pre-lingual / Post-lingual)	13 / 2	12 / 3	χ^2 = 0.24, p = .624

Variable	Experimental Group (n = 15)	Control Group (n = 15)	Statistic / p-value
Baseline Reading Level (Grade Equivalent)	2.1 ± 0.4	2.0 ± 0.5	t = 0.61, p = .547

The baseline results indicate that the two groups were comparable across the demographic and baseline characteristics reported in Table 2.

Technological and Instructional Setup

To address the specific infrastructural constraints of Plateau State, an offline, low-latency edge-computing setup was deployed in the Experimental Group classroom. The system hardware comprised an Intel NUC 12 edge-processing unit with a Core i7 processor and 32GB RAM running an optimised Whisper ASR model locally, requiring no active internet connection.

The classroom teacher wore an FM wireless lapel microphone (Sennheiser EW 112P G4) to capture a direct audio signal and reduce the effects of ambient classroom noise. Transcribed text was streamed in real time onto two 24-inch desk-mounted LED monitors situated adjacent to the certified human sign language interpreter at the front of the classroom. This arrangement allowed pupils to view the teacher, interpreter and text display within a relatively narrow visual field.

Intervention Procedure

The study lasted 14 weeks in total. This comprised one week for the pretest, eight weeks of instructional intervention, one week for the immediate posttest, and a four-week interval before administration of the delayed retention assessment. Both groups were taught identical English language modules derived from the official Nigerian Primary Five curriculum. Instruction focused on science vocabulary, comprehension passages, passive voice structures and specialised terminology. Instructional duration was standardised at 40 minutes per session, four days per week.

Experimental Group

Lessons delivered by the regular subject teacher were simultaneously interpreted into Nigerian Sign Language by a certified human interpreter and transcribed in real time onto student-facing displays using the offline AI engine. During instructional pauses, the teacher pointed to key technical terms displayed on the caption screen to reinforce connections among the spoken word, written form and signed concept.

Control Group

Lessons were delivered by the same subject teacher and interpreted into Nigerian Sign Language by a certified human interpreter using traditional instructional methods. No AI captioning or additional text-display technology was provided during instruction.

Instrument for Data Collection

Data were gathered using the English Literacy and Vocabulary Assessment (ELVA), a 40-item objective test developed by the researchers. The ELVA comprised three subscales:

1. Vocabulary Identification and Orthography — 15 items;
2. Contextual Word Meaning — 15 items; and
3. Passage Reading Comprehension — 10 items.

Total scores ranged from 0 to 100.

Validity and Reliability

Content validity of the ELVA was established through expert review by two professors of Special Education and one measurement expert. Formative pilot testing with an independent cohort of 12 DHH pupils produced a high internal consistency reliability coefficient ($KR-20 = 0.88$). Pretest assessments were administered one week before the intervention, posttests were conducted immediately following the eight-week intervention, and a delayed posttest was administered four weeks later to assess vocabulary retention.

Technical Data Collection

To evaluate technical feasibility, system logs automatically recorded Word Error Rate (WER) across the experimental instructional sessions. WER was calculated as:

$$\text{WER} = (\text{Substitutions} + \text{Deletions} + \text{Insertions}) / \text{Total Spoken Words} \times 100$$

Processing latency was also monitored by the system. However, because a verified numerical latency summary was not available in the supplied study results, no latency statistic has been introduced into the present article. Accordingly, Objective 3 is operationalised in the final article using WER as the reported technical accuracy measure.

Ethical Considerations

Ethical clearance was obtained from the Institutional Review Board of the Federal University of Education, Pankshin. Formal administrative approval was also granted by the Plateau State Ministry of Education and the Principal of Plateau State School for the Deaf, Bassa. Informed parental consent and pupil assent were secured for all participants. Following completion of the study, the Control Group was provided access to the AI captioning hardware to promote educational equity.

Results

Data were analysed using SPSS Version 28. Descriptive statistics, independent-samples t-tests, ANCOVA and paired t-tests were used as appropriate. Preliminary analyses included tests of normality using the Shapiro-Wilk test and homogeneity of variance using Levene's test.

Hypothesis 1

H01: There is no statistically significant difference in posttest English literacy and vocabulary scores between the Experimental Group and Control Group when controlling for pretest performance.

Table 3

Mean Literacy and Vocabulary Performance across Groups

Group	N	Pretest M (SD)	Posttest M (SD)	Mean Gain	Retention M (SD)
Experimental Group (AI + Sign)	15	41.20 (7.14)	74.20 (6.85)	+33.00	71.80 (7.10)
Control Group (Sign Only)	15	40.80 (6.92)	58.40 (7.92)	+17.60	52.60 (8.15)

As shown in Table 3, the Experimental Group recorded a higher posttest mean score ($M = 74.20$, $SD = 6.85$) than the Control Group ($M = 58.40$, $SD = 7.92$). An independent-samples t -test revealed a statistically significant difference between the groups, $t(28) = 5.84$, $p < 0.001$, Cohen's $d = 2.13$. The effect size was very large and favoured the Experimental Group.

To control for potential baseline variation, a one-way ANCOVA was conducted using pretest scores as the covariate. Preliminary checks confirmed equal regression slopes, $F(1, 26) = 0.12$, $p = 0.732$, and homogeneity of variance, $F(1, 28) = 0.38$, $p = 0.542$.

Table 4 ANCOVA Summary for Posttest Literacy Achievement, Controlling for Pretest

Source	Type III SS	df	Mean Square	F	p-value	Partial η^2
Pretest (Covariate)	182.41	1	182.41	3.31	.080	.109
Group (Intervention)	2128.53	1	2128.53	38.65	< .001	.589
Error	1486.26	27	55.05	—	—	—
Total	16742.00	30	—	—	—	—

As presented in Table 4, the main effect of the intervention was statistically significant, $F(1, 27) = 38.65$, $p < 0.001$, partial $\eta^2 = 0.589$. Consequently, H_01 was rejected.

Hypothesis 2

H02: There is no statistically significant difference in delayed posttest vocabulary retention scores between the Experimental Group and the Control Group.

The delayed retention results presented in Table 3 show that the Experimental Group obtained a mean retention score of 71.80 ($SD = 7.10$), whereas the Control Group obtained a mean retention score of 52.60 ($SD = 8.15$). An independent-samples t -test based on the reported group means and standard deviations indicated a statistically significant difference between the groups, approximately $t(28) = 6.88$, $p < 0.001$, Cohen's $d \approx 2.51$. The result favoured the Experimental Group. Consequently, H_02 was rejected.

The finding indicates that pupils who received AI-assisted real-time captioning alongside human sign language interpretation retained significantly more of the targeted vocabulary at the four-week delayed assessment than pupils who received human sign language interpretation alone.

The exact Hypothesis 2 test statistic should be verified against the original SPSS output before publication because the value reported here is calculated from the rounded means and standard deviations in Table 3.

Technical Performance

The technical evaluation recorded an average Word Error Rate of 8.4% across the experimental instructional sessions. This indicates that the locally deployed speech-recognition system achieved a relatively high level of transcription accuracy under the classroom conditions examined. Because no verified numerical processing-latency result was supplied in the original Results section, no latency statistic is reported here. Objective 3 therefore focuses on the documented WER result.

Discussion

The primary empirical finding of this study is that integrating AI-driven real-time captioning alongside human sign language interpretation produced statistically significant gains in English literacy and vocabulary acquisition among Primary Five DHH pupils in Plateau State. The Experimental Group outperformed the Control Group by 15.80 percentage points on the posttest assessment.

The finding supports the proposition underlying Paivio's Dual Coding Theory (Paivio, 1991). Pupils in the Experimental Group received simultaneous visual-nonverbal input through signing and visual-verbal input through captions. The combination may have provided complementary representations that strengthened the association between signed concepts and their written English forms.

The findings also align with Cognitive Load Theory. Rapid fingerspelling for unfamiliar academic vocabulary is transient and requires sustained visual attention. In contrast, real-time captions provide a stable orthographic representation that pupils can reference during instruction. The availability of this textual representation may reduce the cognitive demands associated with reconstructing the spelling of unfamiliar words from rapidly presented fingerspelling.

The retention result is particularly important. Four weeks after the immediate posttest, the Experimental Group retained a substantially higher mean vocabulary score than the Control Group. This suggests that the benefit of the intervention extended beyond immediate achievement. The simultaneous availability of signed concepts and written orthography may have provided repeated opportunities for learners to encode and retrieve new vocabulary.

The findings are also consistent with the importance of curriculum accessibility for deaf and hard-of-hearing learners (Stinson and Cawthon, 2015). Captioning should not be interpreted as a substitute for sign language. Rather, the findings suggest that text-based AI support can provide an additional access route to written English, particularly when pupils encounter unfamiliar or specialised vocabulary.

The technical finding is also significant. The average WER of 8.4% demonstrates that the locally deployed system was capable of producing relatively accurate captions under the conditions examined. This is relevant because caption accuracy is central to the educational usefulness of speech-to-text systems for deaf and hard-of-hearing learners (Matthew, 2020).

The deployment of edge computing was particularly relevant to the Nigerian context. Rather than depending continuously on cloud-based processing, the system processed speech locally, thereby reducing dependence on unstable internet connectivity. This demonstrates the importance of adapting AI-enabled assistive technologies to local infrastructural conditions.

Overall, the results support the use of AI captioning as a complementary orthographic scaffold, rather than as a replacement for human sign language interpretation. The human interpreter remains central to conceptual, linguistic and classroom communication, while AI captioning provides an additional visual representation of English speech.

Conclusion

This study demonstrates that AI-driven real-time captioning can function as an effective orthographic scaffold for enhancing English literacy, vocabulary acquisition and delayed vocabulary retention among Primary Five deaf learners in Nigeria.

When integrated collaboratively with human sign language interpretation, AI captioning provides a stable visual representation of English orthography while preserving the conceptual and linguistic contribution of sign language. The Experimental Group demonstrated significantly higher immediate posttest performance and significantly greater delayed vocabulary retention than the Control Group.

The technical evaluation produced an average Word Error Rate of 8.4% under the classroom conditions examined. The use of offline edge-computing architecture also provides a potentially practical approach to deploying AI-assisted educational technologies in Nigerian special-school environments affected by unreliable internet connectivity.

Recommendations

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

1. Institutional Adoption of Dual Scaffolding: State Ministries of Education and administrators of special schools should consider adopting AI real-time captioning as an

auxiliary instructional technology that complements, rather than replaces, qualified human sign language interpreters.

2. Deployment of Edge-Computing Hardware: Educational technology procurement for special schools should prioritise offline or edge-processing hardware and appropriate microphones capable of improving speech capture in noisy classroom environments.
3. Teacher Capacity Building: Professional development programmes should equip special education teachers with the skills required to use AI captioning effectively, including appropriate speech pacing, clear enunciation, management of specialised vocabulary and integration of captions with sign-supported instruction.
4. Expansion of Empirical Research: Future research should replicate the intervention using larger samples across multiple states and educational levels in Nigeria. Further studies should also investigate AI captioning in other subject areas, including Mathematics, Science, Technology, Engineering and Mathematics (STEM), as well as examine long-term literacy outcomes.

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Digital Platform Use, Gender, and Age Differences in Cyberbullying Experiences Among Adolescents in Ondo State, Nigeria

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Abstract

The rapid expansion of digital communication technologies has increased adolescents' exposure to cyberbullying, thereby raising concerns about its psychological and social consequences. This study examined digital platform use, gender, and age differences in cyberbullying experiences among adolescents in Ondo State, Nigeria. The study adopted a descriptive survey research design. The population comprised adolescents in Ondo State, with a sample of 375 respondents selected through online survey sampling. Data were collected using a structured questionnaire titled "Cyberbullying Questionnaire". The instrument was validated through content validity, while reliability was established using Cronbach Alpha which yielded a coefficient of 0.76 and 0.82 for the two subscales of the instrument. Data were analysed using descriptive and inferential statistics. Findings revealed that cyberbullying was prevalent among adolescents in Ondo State. WhatsApp was the most used digital platform for cyberbullying. There was no significant difference in the cyberbullying experiences of the adolescents by gender ($t(373) = -1.05, p > 0.05$) and by age ($F(4, 370) = 0.554, p > 0.05$). The study concluded that cyberbullying is prevalent among adolescents in Ondo State, and the experiences of both genders and different age groups are the same. It recommended increased gender-inclusive digital literacy programmes, school-based counselling interventions, and stricter policies by digital platform providers to reduce cyberbullying.

Keywords: Digital platforms, gender, age, adolescents, cyberbullying

Introduction

The rapid expansion of digital technologies has seriously transformed the social experiences of adolescents worldwide. Young people increasingly interact with one another through digital platforms. Digital platform use refers to the frequency, purpose, duration and pattern of adolescents' engagement with internet-enabled digital platforms such as social media (Facebook, X (formerly Twitter), Instagram, Snapchat, and TikTok), instant messaging applications (WhatsApp, Telegram, Facebook Messenger, Snapchat, and Kik), online forums and chat rooms, gaming platforms, emails, photo and video-sharing platforms like YouTube, Snapchat, Anonymous Apps and Websites. These platforms have created new opportunities for

communication, learning, and identity formation. However, they have also introduced new risks, particularly the emergence of cyberbullying as a pervasive form of peer aggression among adolescents.

Adolescents are individuals who are in the transitional stage of development between childhood and adulthood. According to the World Health Organisation (2026), adolescence generally covers the age range of 10 to 19 years and is characterised by rapid physical, emotional, cognitive, and social changes. It is a critical developmental period during which young people begin to form their identity, develop independence, establish social relationships, and become more exposed to societal influences, including digital technologies and social media platforms. Adolescents appear to represent a vulnerable group to cyberbullying because they are active users of digital platforms such as WhatsApp, Facebook, Instagram, TikTok, and other online communication channels where cyberbullying frequently occurs. Their frequent online interaction and emotional sensitivity increase their susceptibility to both experiencing and perpetrating cyberbullying, which may subsequently affect their mental health and psychological well-being.

Cyberbullying has been defined in various ways by different researchers. Abaido (2020) defined it as the use of social media to harass and intimidate others. Ray et al. (2024) see cyberbullying as the deliberate use of digital technologies to manipulate, target, and exploit vulnerable individuals through online aggression, harassment, or repeated threats, often involving the sharing of harmful or embarrassing content with the intention of causing psychological and emotional distress, and in some cases resulting in physical harm. In the point of view of Hellfeldt et al. (2019), cyberbullying is a deliberate aggressive behaviour aimed at harming another person through the use of electronic communication or digital devices. Kumar and Goldstein (2020) explained that although it first emerged through electronic mail, cyberbullying has gradually expanded to include a broader range of digital communication channels, such as personal blogs, text messages, and video content shared on streaming platforms like YouTube, as well as, more recently, social media platforms like Instagram, Snapchat, and TikTok. It involves the intentional and repeated use of digital communication platforms to harass, intimidate, embarrass, or inflict harm on another individual. Traditional bullying, which Makinwa (as cited in Makinwa and Akomolafe, 2025) defined as an intentional act of cruelty carried out to oppress, distress or make life difficult for individuals who are less powerful or younger, is carried out physically and reaches a limited number of people at a time. Cyberbullying, by contrast, spreads to a large audience within a very short period.

Empirical evidence indicates that cyberbullying has become a global public health concern, with increasing prevalence among adolescents and significant implications for psychological well-being (Abaido, 2020; Hellfeldt et al., 2019; Kumar and Goldstein, 2020; Mendy et al., 2025; Ray et al., 2024; Schonfeld et al., 2023). This outbreak has been greatly

enhanced by the use of digital platforms through technological devices like smartphones, laptops, and other related devices. Studies have also been conducted in Nigeria to substantiate the prevalence of cyberbullying and its negative consequences on adolescents across the nation (Iqbal and Jami, 2022; Nwosu et al., 2018; Olasanmi et al., 2020) to mention a few.

According to Webster (as cited in Omoteso and Olusegun, 2015), cyberbullying can be classified into seven forms: flaming, masquerading, cyber stalking, exclusion, outing, pseudonym use and harassment. Englander (2019) opined that cyberbullying can occur in form of posting or sending embarrassing or harmful comments and images to a victim, spreading false rumours online, making sexual remarks or gestures, issuing threats through messages, sharing offensive videos or web content about them or impersonating the victim on digital platforms.

The use of digital platform plays a central role in shaping cyberbullying experiences. Platforms such as messaging applications, image-sharing networks, and short-video platforms differ in their structure and affordances, which influence how interactions occur and how harmful behaviours are expressed. For instance, private messaging platforms such as WhatsApp may facilitate covert harassment, while public platforms such as Facebook increase the visibility and potential impact of bullying incidents. Karpagam et al. (2026) observed that widely used digital platforms in cyberbullying include WhatsApp, Facebook, X (formerly Twitter), YouTube, and Instagram. The intensity and nature of platform usage have been shown to significantly predict both exposure to and involvement in cyberbullying.

In addition to digital platform use, individual and contextual factors such as gender and age are critical in understanding cyberbullying. Gender differences in online behaviour have been widely documented, with evidence suggesting that males and females differ in both the forms of cyberbullying they engage in and their responses to victimisation. Additionally, female victims tend to experience outcomes such as social anxiety and sleep disturbances, whereas male victims are more likely to exhibit antisocial behaviours, often influenced by prior negative experiences (Cataldo, 2021). Females are often more vulnerable to relational and emotionally driven forms of cyberbullying, while males are more likely to engage in direct and overt aggression. These differences are shaped by broader socialisation processes and cultural expectations regarding gender roles. Patchin (2025) findings revealed that adolescent boys now report higher rates of cyberbullying victimisation than girls (36.6% compared to 28.6%), marking a shift from earlier years when both groups experienced similar levels. Nonetheless, girls continue to be more frequently targeted by particular types of abuse, such as rumour spreading and image-based harassment.

Age is another variable that could influence cyberbullying experiences. Younger adolescents often possess limited emotional regulation and digital literacy skills. Older adolescents generally spend more time on social networking platforms and maintain larger online peer networks. Mendy et al. (2025) investigated bullying and its effects on mental health among

students of a senior secondary school in Banjul, The Gambia. The mean age of the participants was 17 years, which falls within the 17–19 year age range. Only 9 out of the 167 students recruited for the study did not report experiences and manifestation of bullying which indicated that bullying is more prominent among late adolescents than the young adolescents. Developmental differences in peer relationships, identity formation, and technology use contribute to variations across age groups.

The consequences of cyberbullying extend beyond immediate emotional distress to include serious mental health outcomes. Research consistently links cyberbullying victimisation to depression, anxiety, low self-esteem and, in severe cases, suicidal ideation which Schonfeld et al. (2023) referred to as cyberbullycide. The persistent and often public nature of cyberbullying amplifies its psychological impact, making it a critical issue for adolescent mental health. Given that adolescence is a developmental stage characterised by heightened emotional sensitivity and identity formation, exposure to cyberbullying can have long-lasting effects on well-being and social functioning. Mendy et al. (2025) reported that the most prevalent mental health concerns among the participants in their study were linked to four major areas which included hyperactivity-related issues such as aggression, impulsivity, poor concentration, and easy distraction; peer relationship difficulties; conduct-related problems like stealing, violating others' rights, manipulative behaviour, and substance abuse as well as emotional disorders.

In Nigeria, the rapid adoption of digital technologies among adolescents has not been matched by adequate research, policy development, or intervention strategies addressing cyberbullying. While some studies have explored cyberbullying in urban centres, there is a paucity of context-specific research examining how digital platform use, gender, and age interact to influence cyberbullying experiences. Ondo State has experienced steady growth in digital technology adoption among adolescents. Secondary school students increasingly depend on digital platforms for communication, entertainment, and educational activities. Schools encourage technology supported learning through online assignments, electronic communication, and digital learning resources. These developments increase opportunities for positive educational outcomes. They also expose adolescents to harmful online interactions. Evidence regarding the prevalence, forms, and consequences of cyberbullying within the state remains inadequate. However, limited empirical data exist despite increasing internet penetration and social media usage among young people. Given these gaps, this study examined the interplay between digital platform use, gender, and age differences in shaping cyberbullying experiences and their associated mental health outcomes among adolescents in Ondo State, Nigeria.

Specifically, the study aimed to:

- examine the prevalence of cyberbullying among adolescents in Ondo State.
- investigate the forms of cyberbullying among adolescents in Ondo State.

- identify commonly used digital platforms for cyberbullying among adolescents in Ondo State.
- determine gender differences in cyberbullying experiences among adolescents in Ondo State.
- determine age differences in cyberbullying experiences among adolescents in Ondo State.

Research Questions

The following research questions were raised in the study:

- i. What is the prevalence of cyberbullying among adolescents in Ondo State?
- ii. What forms of cyberbullying are experienced by adolescents in Ondo State?
- iii. Which digital platforms are commonly used for cyberbullying among adolescents in Ondo State?

Research Hypotheses

The following research hypotheses were tested in the study;

- i. There is no significant difference in cyberbullying experiences among adolescents in Ondo State on gender basis.
- ii. There is no significant difference in cyberbullying experiences among adolescents in Ondo State on age basis.

Theoretical Framework

This study used Social Cognitive Theory (SCT) of Bandura (1986). Albert Bandura (1925–2021) was a Canadian-American psychologist and one of the most influential psychologists of the twentieth century. The theory was an expanded framework of social learning theory. The central assumption of SCT is triadic reciprocal determinism, which states that behaviour results from the continuous interaction of personal factors (beliefs, emotions, cognition), behaviour and environmental influences. Secondly, people learn by observing the behaviours of others and the consequences those behaviours receive. Thirdly, people are more likely to imitate behaviours when they believe those behaviours will produce desirable outcomes or social rewards.

The theory is applicable to this study on the principle of reciprocal determinism which explains that cyberbullying experiences among adolescents are influenced simultaneously by personal characteristics (such as age and gender), behavioural patterns (frequency of online interaction and previous cyberbullying involvement), and environmental factors (digital platform characteristics). Adolescents spend considerable time on digital platforms where they are constantly exposed to the behaviours of peers, influencers, and anonymous users. Through observational learning, they imitate aggressive online communication, harassment, insults, or exclusion after witnessing such behaviours being rewarded with likes, comments, followers, or

peer approval. Thus, digital platform use provides an environment where cyberbullying behaviours can easily be learned and reinforced.

The theory further helps to explain the experiences of males and females in cyberbullying. Male adolescents may be more likely to observe and imitate overt aggressive online behaviours if such actions are perceived as socially acceptable within their peer groups, whereas female adolescents may engage more frequently in relational forms of cyberbullying, such as spreading rumours or social exclusion, depending on the behaviours modelled within their social networks. The theory also explains age differences in cyberbullying experiences. Older adolescents generally have greater access to smartphones, broader social networks, increased digital independence, and more exposure to diverse online interactions than younger adolescents. Consequently, they may encounter more opportunities both to observe and to participate in cyberbullying. Conversely, younger adolescents may have more limited exposure due to greater parental monitoring and less autonomy in digital platform use.

Methodology

Descriptive survey research design was used for the study because it allows sample representation of the population which consisted of all the adolescents within the age bracket of 10–19 years old in Ondo State. A sample of 375 adolescents was selected through online survey sampling across institutions of learning in the state. The research instrument was a self-structured questionnaire titled “Cyberbullying Questionnaire” which was in two sections; the Section A was on the demographic data of the respondents like age, gender, level, school type and most used digital platform. Section B comprised 10 items for each of digital platform use and cyberbullying experiences subscales. Items sought information on the respondents’ experiences of cyberbullying, the frequency of those experiences and the types of cyberbullying they had experienced. Digital platform use was measured through adolescents’ self reported frequency, duration, and breadth of engagement with selected digital platforms. Responses were scored on a 4-point scale ranging from 1, Never, to 4, Very Frequently. Higher scores indicated greater levels of digital platform use. The instrument was subjected to content validation by experts in Educational Psychology as well as Test and Measurement. Reliability of the instrument was carried out on 20 adolescents who are not part of the study using Cronbach’s alpha internal consistency which yielded a coefficient of 0.76 and 0.82 for the digital platform use and cyberbullying experiences respectively. This indicated that the items demonstrated good internal consistency and were sufficiently reliable for use in this study.

The instrument was designed with Google form and the adolescents were invited through their WhatsApp group administrators, class teachers and level advisers, after which the Google form link was sent to the different groups. A part of the questionnaire sought parental consent and approval before proceeding to the questionnaire items. Participation was completely

voluntary, participants were assured of anonymity and high level of confidentiality of their responses. The responses were downloaded, coded, and SPSS IBM Version 20 was used to analyse the data. The research questions were answered with frequency counts, percentages, mean and standard deviations while t-test and ANOVA were used to test the hypotheses at 0.05 level of significance.

Results

Research Question 1: What is the prevalence of cyberbullying among adolescents in Ondo State?

Responses of adolescents on their experiences of cyberbullying were collated and analysed using frequency counts and percentages. The result is presented in Table 1.

Table 1

Prevalence of Cyberbullying Among Adolescents in Ondo State

<u>Gender</u>	<u>Yes F(%)</u>	<u>No F(%)</u>	<u>Total F(%)</u>
Male	83 (22.13)	65 (17.33)	148 (39.46)
Female	109 (29.07)	118 (31.47)	227 (60.54)
Total	192 (51.20)	183 (48.80)	375 (100)

Table 1 revealed that 83 (22.13%) males and 109 (29.07%) females, making a total of 192 (51.20%) had experienced cyberbullying among the sample of the study. This indicated that cyberbullying is prevalent among adolescents in Ondo State.

Research Question 2: What forms of cyberbullying are experienced by adolescents in Ondo State?

Responses of adolescents on the forms cyberbullying they had experienced are collated and analysed using frequency counts and percentages. The result is presented in Table 2.

Table 2

Forms of Cyberbullying Experienced by Adolescents in Ondo State

<u>Gender</u>	<u>Threatening or abusive messages f(%)</u>	<u>Exclusion from groups f(%)</u>	<u>Sharing information or images without consent f(%)</u>	<u>Online impersonation f(%)</u>	<u>Other forms f(%)</u>	<u>Total f(%)</u>
Male	28 (7.47)	59 (15.73)	18 (4.8)	30 (8.00)	13 (3.47)	148 (39.47)
Female	40 (10.67)	66 (17.60)	55 (14.67)	34 (9.06)	32 (8.53)	227 (60.53)
Total	68 (18.13)	125 (33.33)	73 (19.47)	64 (17.07)	45 (12.00)	375 (100.00)

Table 2 revealed that 68 (18.13%) of the respondents had experienced threat or abusive messages, 125 (33.33%) experienced exclusion from groups, 73 (19.47%) experienced sharing of their information or images without consent, 64 (17.07%) experienced online impersonation

while 45 (12.00%) experienced other forms of cyberbullying. The most experienced form is exclusion from groups.

Research Question 3: Which digital platforms are commonly used for cyberbullying among adolescents in Ondo State?

Responses on the different digital platforms used for cyberbullying were collated and analysed with frequency counts and percentages. The result is presented in Table 3.

Table 3

Digital Platforms Used by Adolescents in Ondo State

<u>Digital Platform Use</u>	<u>Frequency</u>	<u>Percentage</u>
Facebook	67	18%
X (formerly Twitter)	40	11%
Instagram	58	15%
WhatsApp	167	45%
Others	43	11%
Total	375	100%

Table 3 shows the different digital platforms used by the adolescents, 67 (18%) used Facebook, 40 (11%) used X (formerly Twitter), 58 (15%) used Instagram, 167 (45%) used WhatsApp while 43 (11%) use other digital platforms. Therefore, the most used digital platform for cyberbullying by the adolescents in Ondo State was WhatsApp.

Test of Hypotheses

Hypothesis 1: There is no significant difference in cyberbullying experiences among adolescents in Ondo State on gender basis.

An independent-samples t-test was conducted to examine whether cyberbullying experiences differed significantly by gender. The result is presented in Table 4.

Table 4

Independent-Samples t Test of Cyberbullying Experiences by Gender

<u>Gender</u>	<u>n</u>	<u>M</u>	<u>SD</u>	<u>t</u>	<u>Df</u>	<u>p</u>
Male ^a	148	9.35	2.11	-1.05	373	.295
Female ^b	227	9.57	1.64			

Note. n^a = 148; n^b = 227; M = mean; SD = standard deviation; t = independent-samples t statistic; df = degrees of freedom. p > 0.05.

Table 4 shows the results of independent-samples t-test of cyberbullying experiences by gender. It revealed that male had M = 9.35 and SD = 2.11 while female had M = 9.57 and SD = 1.64. It indicated that there was no significant difference between male adolescents and female adolescents $t(373) = -1.05$, $p > 0.05$ in their experiences of cyberbullying. Therefore, the hypothesis was not rejected.

Hypothesis 2: There is no significant difference in cyberbullying experiences among adolescents in Ondo State on age basis.

Table 5

Means and Standard Deviations of Age Groups on Cyberbullying Experiences

<u>Age</u> <u>in</u> <u>years</u>	<u>N</u>	<u>Mean</u>	<u>Std.</u> <u>Deviation</u>	<u>Std.</u> <u>Error</u>	<u>95%</u> <u>Confidence</u> <u>Interval for</u> <u>Mean</u>	<u>95%</u> <u>Confidence</u> <u>Interval for</u> <u>Mean</u>	<u>Minimum</u>	<u>Maximum</u>
Age in years	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
10-11	6	8.83	.753	.307	8.04	9.62	8	10
12-13	12	9.00	.000	.000	9.00	9.00	9	9
14-15	12	9.42	1.929	.557	8.19	10.64	6	12
16-17	79	9.38	1.417	.159	9.06	9.70	6	14
18-19	266	9.55	1.996	.122	9.31	9.79	4	15
Total	375	9.48	1.838	.095	9.30	9.67	4	15

Table 5 shows the mean scores and standard deviations of the different age groups in this study. Age group 10–11 years had $M = 8.83$ ($SD = 0.73$), 12–13 years had $M = 9.00$ ($SD = 0.000$), 14–15 years had $M = 9.42$ ($SD = 1.929$), 16–17 years had $M = 9.38$ ($SD = 1.417$), 18–19 years had $M = 9.55$ ($SD = 1.996$).

A one-way analysis of variance (ANOVA) was conducted to examine whether cyberbullying experiences differed significantly across the age groups. The results are presented in Table 6.

Table 6

One-Way Analysis of Variance of Cyberbullying Experiences by Age Group

<u>Source</u>	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Between Groups	4.52	4	1.13	0.55	.697
Within Groups	755.48	370	2.04		
Total	760.00	374			

Note. SS = sum of squares; df = degrees of freedom; MS = mean square; F = F value. $p > 0.05$

Table 6 indicated that there was no statistically significant difference in cyberbullying experiences across the age groups, $F(4, 370) = 0.554$, $p > 0.05$. Therefore, the null hypothesis was not rejected.

Discussion

The findings of this study indicated that cyberbullying is prevalent among adolescents in Ondo State, with 51.2% of respondents reporting exposure to at least one form. The most

common form was exclusion from groups. These results align with earlier studies (Abaido, 2020; Hellfeldt et al., 2019; Kumar and Goldstein, 2020) that described cyberbullying as a complex and evolving phenomenon involving harassment, manipulation, and identity-based harm across digital spaces. This pattern reflects the growing dominance of relational and covert forms of online aggression, which are often more psychologically damaging yet harder to detect. The findings also suggest that exclusion and image-based abuse are becoming central features of adolescent online interactions, reinforcing concerns about the subtle but harmful nature of digital peer aggression.

In terms of platforms, WhatsApp was identified as the most common medium for cyberbullying, followed by Facebook. Karpagam et al. (2026) highlighted the significant role of private messaging applications in facilitating covert harassment. While this study found lower usage of other platforms compared to WhatsApp, the difference may reflect regional usage patterns, where messaging applications are more dominant in daily adolescent communication in Nigeria.

The finding that there is no significant difference in cyberbullying experiences between male and female adolescents indicates that gender, by itself, may not be a strong determinant of cyberbullying victimisation among adolescents in Ondo State. Although the descriptive results showed a higher proportion of females reporting cyberbullying experiences, the difference was not statistically significant, suggesting that both genders are similarly vulnerable to online aggression. This finding is consistent with Hellfeldt et al. (2019), who viewed cyberbullying as an aggressive behaviour capable of affecting adolescents across demographic groups, but contrasts with Chun et al. (2020), who reported higher victimisation among females. It also aligns with Patchin (2025), whose findings demonstrate that gender patterns in cyberbullying can change across populations and over time.

The finding may be explained by the increasing similarity in males' and females' use of digital platforms, particularly WhatsApp, which was the most commonly used platform in the present study, thereby providing comparable opportunities for exposure to cyberbullying. This supports Karpagam et al. (2026) and Kumar and Goldstein (2020), who highlighted the role of digital communication platforms in facilitating cyberbullying. Therefore, cyberbullying prevention programmes in Ondo State should adopt a gender-inclusive approach rather than focus on one gender, particularly given the established association between cyberbullying and adverse psychological outcomes such as anxiety, depression, low self-esteem, and suicidal ideation (Schonfeld et al., 2023).

The finding that there is no significant difference in cyberbullying experiences by age indicates that adolescents across the different age groups in the study were similarly exposed to cyberbullying, despite the descriptive result showing that respondents aged 18–19 years reported the highest mean score of experiences. This suggests that age alone may not be a sufficient

determinant of cyberbullying experiences among adolescents in Ondo State. The finding is consistent with Hellfeldt et al. (2019), who conceptualised cyberbullying as an aggressive behaviour that can occur across adolescent age groups. Although Brandau (2019) identified adolescents and young adults as particularly vulnerable to cyberbullying, the present finding suggests that vulnerability may not necessarily differ significantly between specific adolescent age categories. Differences in findings across studies may be attributed to variations in digital engagement, social environments, cultural contexts, and the types of digital platforms used by adolescents.

The non-significant age difference may also be explained by the widespread availability and use of smartphones and digital platforms among adolescents. Younger and older adolescents increasingly participate in similar online environments, including WhatsApp, Facebook, Instagram, and other social networking and messaging platforms, thereby creating comparable opportunities for exposure to cyberbullying. In the present study, WhatsApp was the most frequently used platform, suggesting that frequent engagement with digital platforms may be more important in explaining cyberbullying experiences than chronological age. This interpretation is supported by Karpagam et al. (2026), who identified WhatsApp and other social media platforms as important environments for cyberbullying, while Kumar and Goldstein (2020) noted that the expansion of digital communication channels has increased opportunities for cyberbullying across different forms of online interaction.

Therefore, interventions should address adolescents across age groups rather than target only older or younger adolescents, with emphasis on responsible digital platform use, digital citizenship, online safety, and effective reporting mechanisms. This is particularly important because cyberbullying can have serious psychological consequences, including anxiety, depression, low self-esteem, and suicidal ideation (Schonfeld et al., 2023).

Conclusion

This study concluded that cyberbullying is prevalent among adolescents in Ondo State, Nigeria, with exclusion from online groups the most common form experienced and WhatsApp the most frequently used platform for cyberbullying. The findings further revealed that all adolescents, male or female, young or old experienced cyberbullying.

Recommendations

Based on the findings of this study, it was recommended that schools, parents, counsellors, and policymakers collaborate to develop effective strategies for preventing and addressing cyberbullying among adolescents in Ondo State. Schools should organise regular gender-inclusive digital literacy and cyber safety education programmes to educate students on responsible online behaviour and the dangers of cyberbullying. Counsellors should provide

psychosocial support and intervention services for victims. Parents should closely monitor adolescents' digital activities and encourage open communication regarding online experiences. In addition, social media and digital platform providers should strengthen privacy and reporting mechanisms to curb online harassment, while government and educational stakeholders should formulate policies and awareness campaigns aimed at promoting safe digital engagement and protecting adolescents' mental health.

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Self-Reported Utilisation Patterns of Artificial Intelligence-Generated Feedback Among Undergraduate Science Students in Tertiary Institutions in Kwara State, Nigeria

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Abstract

The study investigated the self-reported utilization patterns of artificial intelligence-generated feedback among undergraduate science education students in three public universities in Ilorin, Kwara State. The study was a descriptive of survey type. The population of the study comprises all undergraduate science education students offering biology and computer science education in the three public universities in Ilorin metropolis, kwara state. The sample size was 397 respondents which comprising 146 male and 251 female students. A purposive sampling technique was used to select the institutions and simple random sampling to select respondents from each department. The instrument for data collection was a researcher designed copies of questionnaire entitled “Students Artificial Intelligence feedback pattern” (SAIFP)“. The Research instrument was given to three experienced science educators from the Department of Science Education, University of Ilorin, Nigeria for face and content validity. Also, the draft of the instrument was given to an expert in the field of measurement and evaluation for standard of the items. A reliability of 0.74 was obtained using Cronbach Alpha. Mean and standard deviation was used to answer the research questions, while t-test statistic was used to test the hypotheses at 0.05 level of significance. The study found out that AI-generated feedback utilization was high as reported by undergraduate students to support independent learning. Also, students encounter challenges that limit effective utilization, particularly issues related to technological accessibility, digital competence among others. The findings further revealed that gender does not determine students’ use of AI-generated feedback or the challenges they experience. It was recommended among others Universities should introduce structured AI literacy programmes to equip students with the knowledge and skills required to use AI-generated feedback to improve learning and every students be provided similar opportunities to access AI-based learning resources in the

institutions. As digital learning environments become more common in educational institutions, students' technology adoption may increase irrespective of gender

Keywords: *Patterns of Use, Artificial Intelligence, Generated Feedback, Undergraduate, Science Students, Tertiary Institutions*

Introduction

Artificial Intelligence (AI) has significantly reshaped science education through automated feedback systems, intelligent tutoring, and adaptive learning environments. Artificial Intelligence has been defined as the science and engineering of making intelligent machines. It has been proven to aid a positive influence on human life (Awofiranye, 2024). It is a technology that modifies educational tools and institutions by changing the teacher's job through advanced analytics, deeper learning and machine learning to monitor the speed of individuals. It increases proficiency of education by identifying the gaps in teaching and learning processes. It tends to explore and integrate into education a promising future as it improves learning, making it a valuable ally for progress and evolution in higher education (Ramirez & Fuentes Esparrell, 2024).

Artificial intelligence applications can directly enhance learning capabilities, save time, and obtain quick information for teaching and learning. Educators play a crucial role in the teaching-learning process by implementing interactive strategies that enable students to use AI applications to acquire new skills and knowledge, leading to better learning outcomes (Sirghi, et al., 2023). Enhancing the overall teaching experience and quality, AI systems are used to support the teacher and reduce workload by automating tasks such as administration, assessment, feedback, and plagiarism. AI helps educators have greater insight as to how students are progressing as well as adopting an approach for supporting students' individual differences. Furthermore, AI could foster the development of smart content and platforms for professional development of teachers. (Onaolapo and Onifade, 2020). The educational value of AI cannot be determined solely by the sophistication of the technology. AI becomes educationally meaningful when its application enhances teaching and learning processes through its feedback.

Feedback is very paramount in teaching and learning in education. In higher education, it helps students to understand their errors and improve their expression and clarity of ideas (Pang et al. 2024). Feedback encompasses the abilities of both learners and educators to comprehend, engage and benefit from it processes as well as highlighting their mutual responsibility in process (Boud & Dawson, 2023; Carless & Boud 2018). Feedback being universally acknowledged as a critical factor in educational success, its effective delivery and reception by students remains challenging (Carless and Winstone, 2023 & Yiğit and Seferoğlu, 2023). In recent times, researches have continued to emphasize AI-generated feedback as a key innovation that enhances formative assessment, learner engagement, and conceptual understanding in science

education. AI tools support scientific reasoning by analyzing student responses and generating instructional feedback in real time. He and Krajcik (2026) reported that AI technologies, including machine learning and large language models, are transforming science education by enabling personalized feedback and scalable instructional support.

Agostini and Picasso (2026) found that AI-generated feedback becomes more effective when guided by well-defined rubrics and contextual prompts, emphasizing the importance of instructional design in AI systems. In same vein, Xia et al. (2026) demonstrated that AI feedback guided by learning progressions is comparable in quality to expert-designed rubric-based feedback, with no significant differences in clarity, relevance, and engagement. In online science-related courses, generative AI feedback significantly improves student satisfaction and engagement, particularly when feedback is timely and actionable (Merodio et al., 2025). However, learners tend to prefer AI feedback when it complements rather than replaces human instructor feedback. Therefore, In this study, ***AI-generated feedback refers to automated generated comments, explanations, corrections or recommendations by artificial intelligence system that assist learners to provide answers or solve problems or assignments, clarify concepts or ambiguous words, simplifies learning with the purpose of helping the learners identify their strength and weaknesses , thus improving subsequent learning or performance.***

Several studies have been conducted on AI- generated feedback, among which was Li, et. al, (2026). Study on evaluating AI-generated feedback for formative assessment in higher education in Griffith University, Australia. The findings from the study revealed that AI-generated feedback provides structured and detailed comments for assessment components based on clear and objective criteria, with strong agreement with human marking practices. Findings from the study emphasised on the importance of human oversight for qualitative and interpretive evaluation. It was recommended that a balanced human-AI approach, grounded in pedagogical intent and careful integration, is essential for t effective adoption of AI-assisted feedback in higher education. Venter, et al. (2025). Explored the use of artificial intelligence in effective feedback delivery. The study focused on the development of a custom prompt for GPT-4 within a no-code web application, designed to deliver AI-generated feedback to second-year accounting students on discussion or essay-style questions in a large competency-based intermediate accounting course in South Africa. The prompt aligns with the principles of effective feedback and was tested in a pilot evaluation. Results indicated that the AI-generated feedback generally adhered to these principles, though some variability was observed across the different feedback dimensions. Findings revealed that large language models can complement traditional feedback. Danjuma (2025) studied the potential of Artificial Intelligence (AI) in enhancing assessment in Basic Science Education in Jalingo Education Zone, Taraba State, Nigeria. The findings revealed that AI tools can enhance feedback by making it faster, more accurate, and more consistent, thereby addressing delays associated with traditional teacher-based feedback. The study also,

highlighted the potential benefits of AI tools in improving assessment practices. It was recommended that science educators receive training to effectively use Artificial Intelligence tools in their assessments, and that policymakers should develop and implement AI-based assessment tools. Akintokun and Bolarinwa(2025) investigated the impact of artificial intelligence as a science education tool for enhancing academic experience of students in Federal College of Education (Special), Nigeria. The study showed that AI enhances feedback and learning engagement but a Low level of institutional AI integration. Agbarakwe and Chibueze (2024) conducted a study on leveraging artificial intelligence for enhanced assessment and feedback mechanisms in Nigeria higher education system in University of Port Harcourt, Nigeria. It was an analytical study The study argues that AI can significantly improve feedback by enabling real-time responses, automated grading, and personalized learning support, which are critical in science education where timely correction enhances conceptual understanding. It also discussed ethical concerns, data privacy issues, and digital literacy gaps as barriers to effective adoption.

The potential of AI-generated feedback is responding to the long-standing challenges of providing timely feedback to learners. Lee and Moore (2024), in a systematic review of empirical studies published between 2019 and 2023, analysed the use of generative AI for automated feedback in higher education. This review revealed that generative AI had been used to provide different forms of feedback across instructional contexts and could alleviate instructors' workload by automating repetitive feedback and grading activities. However, challenges were identified , indicating that the presence of an automated feedback mechanism does not automatically guarantee effective learning. However, the increasing advocate for the adoption of AI in education to meet up global development in this era of technological advancement has paved way for transforming teaching and learning. AI has been proved to providing students with instant, personalized, and adaptive feedback that can improve understanding, academic performance, and independent learning. AI-generated feedback is increasingly being used to support assignments, assessments, and other learning activities. Despite these importance, concerns have been raised on how students utilize this feedback in their learning processes. In Nigerian universities, there is limited empirical evidence on students' patterns of using AI-generated feedback. As a result, it remains unclear whether students use AI feedback to support meaningful learning or simply as a convenient means of completing academic tasks. This gap in knowledge was the rationale behind this present study. Therefore, this study investigated students' self-reported patterns of use of AI-generated feedback, with a view to providing evidence that will inform the integration of AI technologies into teaching and learning in tertiary institutions.

Research Questions

1. What is the level of pattern of use of AI-generated feedback in learning by undergraduate science education students?
2. Does difference exists in the self-reported pattern of use of AI-generated feedback in learning based on gender.
3. What challenges do undergraduate science education students encounter in using AI-generated feedback?

Hypotheses

1. There is no significant difference in the self-reported pattern of use of male and female undergraduate science education students toward AI-generated feedback in learning.
2. There is no significant difference between male and female undergraduate science education students in the challenges they encounter in using AI-generated feedback in learning

Methodology

The study was a ***descriptive research of survey type***. The population comprises all undergraduate students in the three purposively selected public universities in Ilorin metropolis, Kwara state. Students from offering Science education with specialization in biology and computer. A sample comprise of 397 undergraduate students study biology education and computer education. A purposive sampling technique was used to select the institutions and simple random sampling to select respondents from the two departments. The sample comprise of 146 male and 251 female students. A researcher designed copies of questionnaire entitled “Students Artificial Intelligence feedback pattern” (SAIFP)” was used for data collection. The Research instrument was given to three experienced science educators from the Department of Science Education, University of Ilorin, Nigeria for face and content validity. Also, the draft of the instrument was given to an expert in the field of measurement and evaluation for standard of the items. A reliability of 0.74 was obtained using Cronbach Alpha. Mean and standard deviation was used to answer the research questions, while t-test statistic was used to test the hypotheses at 0.05 level of significance. The questionnaire consisted of three sections: section A: Demographic Information consisted of gender; age; department and frequency of AI tool usage. Section B: pattern of use of AI-generated feedback. Section C: ***challenges encounter in using AI-generated feedback in learning in my university*** The instrument contained eight items for Section B and C each. Respondents indicate their level of agreement on a 4-point likert scale: Strongly Agree (SA) = 4, Agree (A) = 3 Disagree (D) = 2 and Strongly Disagree (SD) = 1.. Data collected were analysed using mean, standard deviation and t-test statistic at 0.05 level of significance. The researcher

and research assistants visited the institutions and distributed the copies of the questionnaires to the respondents personally.

Data Analysis and Results

Data collected were analysed using mean, standard deviation for research questions. **Decision Rule used for the results were;** 3.50–4.00 = Very High, 2.50–3.49 = High, 1.50–2.49 = Low and 1.00–1.49 = Very Low

Research Question 1: What is the pattern of use of AI-generated feedback in learning by undergraduate science students?

Table 1: Mean and Standard Deviation on the Patterns of Use of AI-generated Feedback among Science Students

S/N	Pattern of Use	Mean ($\bar{x}$)	SD	Decision
1.	I rely on AI-generated feedback to identify my mistakes.	3.36	0.79	Agree
2.	I use AI-generated feedback for examination preparation.	3.27	0.81	Agree
3.	AI-generated feedback helps me study independently.	3.48	0.70	Agree
4.	I compare AI-generated feedback with lecturers' comments.	3.18	0.87	Agree
5.	I verify AI-generated feedback before applying it.	3.11	0.86	Agree
6.	I use AI-generated feedback to improve my assignments.	3.42	0.71	Agree
7.	I use AI-generated feedback before submitting coursework.	3.31	0.83	Agree
8.	I use AI-generated feedback regularly during learning.	3.29	0.77	Agree
	Grand mean	3.30	0.79	High

Table 1 revealed that respondents exhibited high patterns of AI-generated feedback in learning. As the grand mean was 3.30 ($SD = 0.79$)

Research Question 2: Does difference exists in the self-reported pattern of use of AI-generated feedback in learning based on gender.

Table 2: Mean and Standard Deviation of Science education Students on the Patterns of Use of AI-generated Feedback based on Gender

Gender	N	Mean($\bar{x}$)	SD
Male	146	3.24	0.53
Female	251	3.34	0.48

Table 2 shows that female students obtained a slightly higher mean score (3.34) than male students (3.24), suggesting a marginally higher pattern of use of AI-generated feedback

among female students. **Therefore, there was a marginal difference in the patterns of use of AI-generated feedback in learning by the respondents based on gender**

2.2 Research Question 3: *What challenges do undergraduate science education students encounter in using AI-generated feedback in learning?

Table 3: Mean and Standard Deviation on the Challenges encountered by Science Students in Using AI-generated Feedback

S/N	Challenge	Mean	SD	Decision
1.	Difficulty interpreting technical feedback.	3.12	0.86	Agree
2.	Limited digital literacy.	3.09	0.84	Agree
3.	Lack of institutional guidance on AI use.	3.34	0.75	Agree
4.	Overdependence on AI-generated responses.	3.28	0.77	Agree
5.	Limited internet connectivity.	3.47	0.69	Agree
6.	Difficulty determining the accuracy of AI feedback.	3.25	0.82	Agree
7.	High cost of internet subscription.	3.39	0.74	Agree
8.	Inconsistent quality of AI-generated feedback.	3.20	0.81	Agree
<i>Grand Mean</i>		<i>3.27</i>	<i>0.79</i>	<i>High</i>

Table 3 indicates students responses to the challenges in using AI-generated feedback during learning. Limited internet connectivity and high cost of internet subscription had the high means among the challenges. The grand mean of 3.27 (SD=079) revealed a high acceptances of these challenges by the respondents

H0₁: There is no significant difference in the self-reported pattern of use of male and female undergraduate science students toward AI-generated feedback in learning.

Table 4: Independent Samples t-test on the Patterns of Use of AI-generated Feedback by Gender

Gender	N	Mean	SD	df	t-cal	Sig. (2-tailed)	Decision
Male	146	3.24	0.53	395	1.82	0.070	Not Significant
Female	251	3.34	0.48				

Table 4 shows that the calculated value p is 0.070 greater than the significant 0.05, hypothesis one is not rejected. Therefore, there is **no significant difference** between male and female undergraduate science education students in their patterns of use of AI-generated feedback in learning.

H0₂: There is no significant difference between male and female undergraduate science education students in the challenges they encounter in using AI-generated feedback in learning

Table 5:Independent Samples t-test on the Challenges Encountered in Using AI-generated Feedback by Gender

Gender	N	Mean	SD	df	t-cal	Sig. (2-tailed)	Decision
Male	146	3.23	0.55	395	0.96	0.338	Not Significant

Gender	N	Mean	SD	df	t-cal	Sig. (2-tailed)	Decision
Female	251	3.29	0.50				

Table 5 shows that the calculated value p is **0.338** greater than the significant **0.05**, the null hypothesis is **therefore not rejected**. This implies that there is **no statistically significant difference** between male and female science education undergraduate students' responses to challenges they encounter in using AI-generated feedback in learning

Discussion of Findings

This study revealed that undergraduate students use AI-generated feedback to improve learning. This provided evidence for undergraduate students utilisation of AI technologies in learning in tertiary institutions in Kwara State. The findings revealed that undergraduate students use AI-generated feedback as a learning support tool in improving assignments, identifying learning difficulties, clarifying concepts, and independent learning among others. This supports the findings of Agbarakwe and Chibueze (2024) that artificial intelligence has the potential to enhance formative assessment by providing timely and adaptive feedback that promotes conceptual understanding and self-regulated learning. The findings also, revealed that gender had a significant influence on students' utilization of AI-generated feedback in learning. The result suggests that gender may not be a major factor determining students' adoption of AI-generated feedback. This could be attributed to the availability of digital technologies, factors, accessibility, attitude, and perceived usefulness rather than gender. This is in line with the International Telecommunication Union (2023) reported that gender differences in internet access and digital participation continue to exist globally but are gradually influenced by broader improvements in connectivity and digital development. As well as Scherer, et.al (2020) that these differences in gender were shaped by experience, accessibility, and technological confidence rather than gender alone. In additions, male and female undergraduate science students differed significantly in the challenges they experienced while using AI-generated feedback. This implies that the difficulties associated with AI use are largely related to problems of internet connectivity, high data, subscription digital, competence, among others (Zawacki-Richter, et al., 2019).

Conclusion

The outcomes of this study concluded that AI-generated feedback has become an emerging learning resource among science education students in the sampled university in Ilorin. Students use AI-generated feedback significantly to improve personalized learning experiences, and promoted better student engagement in the three public universities in Ilorin metropolis. Students utilize AI-generated feedback for different academic purposes, including improving understanding, correcting errors, enhancing assignments, and supporting independent learning. However, despite its benefits, students encounter challenges that may limit effective utilization,

particularly issues related to technological accessibility, digital competence, e.tc. The findings further suggest that gender does not necessarily determine students' use of AI-generated feedback or the challenges they experience.

Recommendations

Based on the findings, the researcher recommended that:

1. Universities should introduce structured AI literacy programmes to equip students with the knowledge and skills required to use AI-generated feedback to improve learning.
2. All students be provided similar opportunities to access AI-based learning resources in the institutions. As digital learning environments become more common in educational institutions, students' technology adoption may increase irrespective of gender.
3. Institutions should improve access to reliable internet connectivity, digital devices, and technology-enabled learning facilities ensure that all learners can benefit from AI-supported learning opportunities.

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ICT Proficiency Needs of Agricultural Education Lecturers for Instructional Purposes in Tertiary Institutions in South Western Nigeria

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Abstract

This study assessed the information and communication technology (ICT) proficiency requirements of lecturers in agricultural education for instructional purposes in tertiary institutions in Southwest Nigeria. Descriptive survey research design was used. The study population consisted of 297 agricultural education lecturers and technologists in the six states in Southwest Nigeria. The method of sample selection involved multistage sampling technique where three out of the six states in the region – Lagos, Ondo and Oyo states were randomly selected. From each of the sampled states, the census/total population sampling technique was used to select 157 respondents which comprises of 92 lecturers and 65 technologists. The instrument used was a structured questionnaire (PSNBAEDQ), whose internal reliability yielded a Cronbach Alpha of 0.99. Percentage and Improvement Need Gap (ING) index were used for data analysis. Findings showed that 27 of the 30 listed ICT facilities and tools were considered needed. The overall ING value of 1.44 indicated that proficiency training was required in 89 of the 93 skill items examined across general ICT knowledge, word-processing and spreadsheet applications. It is recommended that tertiary institutions organise sustained in-service training on ICT integration, that governments and partners invest in relevant infrastructure, and that the agricultural education curriculum be reviewed to embed digital pedagogies systematically.

Keywords: ICT proficiency, agricultural education lecturers, instructional purposes, tertiary institutions, Southwestern Nigeria

1. Introduction

Agricultural education in tertiary institutions plays a pivotal role in equipping graduates with the knowledge and practical skills required to enhance food production, promote sustainable resource use and support national development. In an era of rapid technological change and rising global food demand, the quality of instructional delivery in agricultural education has

direct implications for agricultural productivity and the attractiveness of the sector to young people (FAO, 2021; Schneider, 2016).

Educational practices in the twenty-first century require approaches that encourage critical thinking, cooperation, problem-solving and continuous learning. However, teacher-centred practices are becoming less appropriate for preparing learners for work in the age of technologies. This is why teachers are supposed to utilise learner-centred approaches and incorporate ICT in order to make learning more interesting, interactive and practical (UNESCO, 2021; Anderson and Brown, 2019).

The role of Information and Communication Technologies in the above process is hard to underestimate. ICT incorporated into agricultural education will make it possible to gain access to the most recent information, simulate and visualise agricultural processes, collaborate and provide flexible educational methods. Learning management systems, multimedia sources, statistical software and mobile technologies can help to enrich learners' conceptual knowledge and prepare them for future use of digital skills (Krouska et al., 2019; Njura et al., 2020).

While all these advantages have been noted, many agricultural education lecturers in Nigeria's tertiary institutions still experience difficulties because of poor digital skills, lack of proper infrastructure, poor power supply and inadequate institutional support. Many lecturers were trained within the traditional educational systems, where little emphasis was put on ICT-based training and capacity building (Ajie-Uche et al., 2018; Oyefara et al., 2021). This is why the full potential of ICT in enriching agriculture education has not yet been realised.

Several scholars have looked into the ICT competencies of teachers in Nigeria but very few have looked into the competencies required by agricultural education lecturers and technologists in Southwestern Nigeria. It is only after pinpointing these exact facilities and competencies that one can begin working on capacity building of such lecturers. This is why this study endeavoured to find out the ICT facilities required by agricultural education lecturers and their proficiency skills for teaching purposes.

Objectives of the Study

The major objective of this study was to identify the proficiency skills needed by agricultural education lecturers' in the utilisation of information and communication technology for pedagogical effectiveness in tertiary institutions of south-west, Nigeria. Specifically, the study sought to identify;

- i. the ICT facilities and tools needed by Agricultural Education Lecturers' in the utilisation of information and communication technology for instructional purposes in tertiary institutions of south-west, Nigeria.
- ii. the proficiency skills needed by Agricultural Education Lecturers' in the utilisation of information and communication technology for instructional purposes in tertiary institutions of south-west, Nigeria.

Research Questions

The following research questions guided the study;

- i. What are the ICT facilities and tools needed by Agricultural Education Lecturers' in the utilisation of information and communication technology for instructional purposes in tertiary institutions of south-west, Nigeria?
- ii. What are the proficiency skills needed by Agricultural Education Lecturers' for instructional purposes in the utilisation of information and communication technology for instructional purposes in tertiary institutions of south-west, Nigeria?

Empirical Review of ICT Utilisation in Nigeria

Earlier studies done at Nigerian tertiary institutions show that the average ICT competence level among lecturers is moderately high but with deficiencies in higher-level applications that are necessary for effective integration of ICT in teaching. Alfred and Ekhovbiye (2021), for example, in evaluating the ICT competency level of vocational teacher educators at the South-South geopolitical zone of Nigeria, found out that the overall mean level of proficiency was moderately high at 3.11, while significant inadequacies existed in higher-level software and interactive ICT applications. In a general study in universities, ICT has been applied moderately for teaching and research purposes (Shiekuma et al., 2020).

Specific research conducted on the issue of technical competencies makes the point that productivity and presentation capabilities become even more important in this regard. According to Okoye and Ugwugwo (2021), productivity and presentation skills are critical to the successful implementation of business education programmes, while Ajie-Uche et al. (2018) found a considerable need for training business education lecturers in multimedia and spreadsheet applications in the South-South region.

Bakare et al. (2019) proved that there are nine important proficiencies related to the Internet among vocational and technology teachers. Overall, these studies show that the set of applications like word processing, spreadsheets, graphics and internet capabilities continues to remain fundamental but unmet among a considerable number of tertiary level educators. There is empirical proof that the availability and usage of particular hardware and peripheral equipment contributes to the increase in instructional quality.

According to Oyefara et al. (2021), among 1,325 middle-level academics surveyed, those who used tablets performed 1.5 times better, and those using multimedia projectors were 2.7 times better trainers. It is from the same context that Michika and Manabete (2019) found the critical skills required in the use of digital cameras, scanners, and LCD projectors by lecturers in the North-East polytechnics. From these findings, it is evident that ICT competence entails the use of software skills and manipulation of teaching equipment.

The importance of capacity building through professional development is emphasised in the literature. Nwabueze et al. (2018) observed the need for urgent capacity building in data storage, applications and presentation among education lecturers, while Igbongidi (2018) established that even basic word processing and data processing knowledge are still important fundamentals at the lower levels of education. All in all, from the literature, it can be seen that there is a pattern in the country that access to ICT resources does not necessarily mean proper pedagogical use of those ICTs. It should be noted that there is a lack of research on agricultural education lecturers and technologists in Southwestern Nigeria.

Theoretical Framework

The study draws upon the theoretical framework of Technological Pedagogical Content Knowledge (TPACK) (Mishra and Koehler, 2006). According to TPACK theory, the successful integration of technologies in education presupposes the interaction between three major types of knowledge, namely content knowledge (knowledge about a subject matter), pedagogical knowledge (methods of teaching), and technological knowledge (understanding digital tools and their capabilities). Moreover, the framework stresses the intersection between these types of knowledge – technological pedagogical knowledge, technological content knowledge, and pedagogical content knowledge.

Within the realm of agriculture education, teachers should have not only comprehensive knowledge in agricultural science and pedagogical knowledge but also technological knowledge for choosing, adapting and using ICTs to facilitate the process of teaching agricultural concepts and skills. The competencies studied in this paper relate mostly to the technological knowledge and technological pedagogical knowledge of TPACK.

Methodology

A descriptive survey design was used in this study, and it was carried out in Southwest Nigeria. The sample population was made up of 297 agricultural education lecturers and technologists from the six states that make up Southwestern Nigeria. A multistage sampling technique was used. First, three states were randomly selected (Lagos, Ondo and Oyo). The census/total population sampling technique was then used to select the respondents in the selected states, leading to 157 participants (92 lecturers and 65 technologists).

The research instrument used was a structured questionnaire entitled “Proficiency Skills Needed by Agricultural Education Lecturers Questionnaire” (PSNBAEDQ). It had three parts: (a) demographic data, (b) list of 30 ICT facilities and tools that required either “Needed” or “Not Needed” answers, and (c) 93 proficiency skills grouped into three clusters (general ICT knowledge, word-processing skills and spreadsheet skills). Proficiency skills were measured on a four-point scale of need and a four-point scale of performance. This instrument was face-

validated by two agricultural education and one educational technology experts. Its reliability was 0.99, as calculated using the Cronbach alpha technique. Even though this reliability coefficient is high, it is partly due to the large number of closely related items in each cluster of skills. The analysis of data was done using SPSS software version 26. Percentages provided answers to research question 1. For research question 2, the Improvement Need Gap (ING) was determined by subtracting the mean rating of need (X_n) from the mean rating of performance (X_p). If the gap was positive, then additional training was needed. If the gap was negative or equal to zero, then performance met or surpassed need.

Results

Research Question 1: What are the ICT facilities and tools needed by Agricultural Education Lecturers' in the utilisation of information and communication technology for instructional purposes in tertiary institutions of south-west, Nigeria?

Table 1

Percentage Responses of Agricultural Education Lecturers and Technologists on the ICT Facilities and Tools Needed for Instructional Purposes

S/N	ICT FACILITIES AND TOOLS	NEEDED	NOT NEEDED	% NEEDED	% NOT NEEDED
1	Desktops and Laptops	131	26	83.4	16.5
2	LED Television	136	21	86.6	13.3
3	Radio	107	50	68.1	31.8
4	Audiotape players	129	28	82.1	17.8
5	Video player/Recorder	148	9	94.2	5.7
6	Fax machine	26	131	16.5	83.4
7	Printers	148	9	94.2	5.7
8	Photocopiers	148	9	94.2	5.7
9	Scanners	132	25	84.0	15.9
10	Floppy diskettes	114	43	72.6	27.4
11	Multimedia Projector	118	39	75.1	24.8
12	Interactive white board/ Smart Board (Triumph Board, Genec touch etc.)	148	9	94.2	5.7
13	Projector screen	118	39	75.1	24.8
14	Megaphone/microphone	133	24	84.7	15.3
15	Speakers	121	36	77.0	22.9
16	Websites of Institutions	134	23	85.4	14.6
17	Internet	114	43	72.6	27.4
18	e-book	133	24	84.7	15.3
19	Digital camera (webcam)	122	35	77.7	22.3

S/N	ICT FACILITIES AND TOOLS	NEEDED	NOT NEEDED	% NEEDED	% NOT NEEDED
20	Fingerprint reader	127	30	80.9	19.1
21	Flash Drive	148	9	94.3	5.7
22	External drive	153	4	97.5	2.5
23	Graphic Packages (e.g. Adobe Photoshop, Corel Draw, AutoCAD, Adobe framework, 3D movie maker, PC paintbrush est.)	122	32	79.2	20.8
24	E-mail (Gmail, Yahoo Mail etc.)	144	13	91.7	8.3
25	Handhelds/Tables computers (iPad)/other mobile devices (smart Phones)	145	12	92.4	7.6
26	Satellite systems	50	107	31.8	68.2
27	Joystick	76	81	48.4	51.6
28	Statistical Packages (SPSS, R, Python, Minitab etc.)	127	30	80.9	19.1
29	Learning Management Systems (e.g. Google Classroom, Moodle etc.)	109	48	69.4	30.6
30	Electronic Bulletin board	137	20	87.3	12.7

Note. Source: Field Survey, 2022

Table 1 revealed that twenty-seven of the thirty ICT facilities were considered necessary by respondents. The most highly rated facilities included external drives (97.5%), video players (94.2%), printers (94.2%), smart boards (94.2%), and flash drives (94.3%). Fax machines, satellite systems, and joysticks were considered less relevant.

Research question 2: What are the proficiency skills needed by Agricultural Education Lecturers' for instructional purposes in the utilisation of information and communication technology for instructional purposes in tertiary institutions of south-west, Nigeria?

Table 2

Means and Standard Deviations of Responses on Proficiency Skills Needed for Instructional Purposes: General ICT Knowledge

Cluster 1: General knowledge	Cluster 1: General knowledge		Level of Need	Level of Need	Level of performanc e	Level of performanc e
S/N	ITEM STATEMENTS	N	XN	Deviation		
1	Ability to operate the different computer operating systems.	157	3.6369	.54482	2.2038	1.07857
2	Ability to use e-mail for instructional purposes	157	3.5860	.78483	2.8153	.96624
3	Ability to use multimedia facilities to deliver instructions in the classroom.	157	3.8471	.36101	2.1338	1.05670
4	Ability to use ICT-friendly learning tools which are beneficial to learners in finding and processing information.	157	3.0637	.91063	2.2102	.92703
5	Ability to use ICT-friendly learning tools which are beneficial to learners in collaborating with peers.	157	3.1911	.66152	1.9172	.97377
6	Ability to use varieties of software like- word processing, database, spreadsheet and statistical software.	157	3.8344	.37292	1.6752	.87864
7	Ability to use ICT knowledge in writing general computer programs for delivering instructions.	157	3.7452	.57629	1.6561	.72247
8	Ability to use ICT-friendly learning tools in evaluating learning effects in concrete ways.	157	3.7389	.57897	1.6561	.72247
9	Ability to use ICT skills in developing and presenting information to learners.	157	3.7134	.48106	2.0000	1.15470
10	Ability to use ICT knowledge to utilize the learning management system,	157	3.0191	.56012	2.5287	.99073
11	Ability to use the computer for power point presentation during lectures	157	3.5860	.63088	3.8471	.36101
12	Ability to use drill-and-practice software to support pervasive learning.	157	3.7707	.56469	2.0573	.76159
13	Ability to use ICT knowledge in delivering lectures with different instructional packages.	157	3.0892	.90848	2.1911	1.08683
14	Ability to use ICT to monitor and evaluate the teaching-learning process.	157	3.8726	.33447	2.0000	1.01274

Cluster 1: General knowledge	Cluster 1: General knowledge		Level of Need	Level of Need	Level of performanc e	Level of performanc e
15	Ability to use the internet to download educational materials to enrich learning.	157	3.8599	.34823	2.0510	1.04879
16	Ability to use ICT to Select and evaluate subject-specific educational software.	157	3.7070	.63307	1.8854	.96721
17	Ability to use ICT knowledge to Develop and maintain educational websites.	157	3.5032	.90316	2.1783	1.05917
18	Ability to Prepare ICT-based learning environment.	157	2.1529	1.11036	2.1592	1.00963
19	Ability to use ICT knowledge to develop educational programs with the help of programming languages.	156	2.2179	1.10304	1.8790	.85747
20	Ability to use spreadsheet for mathematical calculations during the teaching-learning process.	157	3.6624	.61555	1.8599	.88765
21	Ability to use ICT Application to support strategies to manage students' learning.	157	3.3949	.93204	1.8153	.86840
22	Ability to design effective learning experiences and creating rich learning environments with the support of ICT.	157	3.5924	.73341	1.8344	.90474
23	Ability to use ICT in locating useful information from the internet for the development of lesson plans.	157	3.5223	.87403	1.8535	.90451
24	Ability to use ICT to integrate different subjects fields across the curriculum.	157	2.3503	.97314	1.7962	.86779
25	Ability to use ICT to Prepare instructional notes to be delivered to learners.	157	3.4204	.95493	2.1592	1.19029
26	Ability to explore and apply to suitability of ICT for cooperative learning and for peer interaction.	157	3.6561	.64761	1.7643	.81760
27	Ability to use ICT tools to create and facilitate a community of learning.	157	3.4459	.85781	1.9936	.99677
28	Ability to use Microsoft Excel for data analysis during instructional delivery.	157	3.6497	.66858	1.9618	1.02460
29	Ability to use ICT knowledge to format tables using special software packages.	157	3.5924	.77588	1.8217	.92337
30	Ability to use ICT to give assignment/wrap assessments on topics taught.	157	3.7834	.54677	1.7898	.86995

Cluster 1: General knowledge	Cluster 1: General knowledge		Level of Need	Level of Need	Level of performanc e	Level of performanc e
31	Ability to use ICT live streaming tools to support specific online teaching/remote learning	157	3.4522	.90897	1.8471	.89275
32	Ability to use ICT knowledge to make decisions about different learning methodologies appropriate to knowledge and experience of learners.	157	3.5159	.84433	1.6815	.85514
33	Ability to use ICT to design the feedback and evaluation for the taught concept.	157	3.5096	.84442	1.9236	.93741
34	Ability to use ICT to create activities related to specific aims/objectives.	157	3.4841	.88871	1.8599	.90198

Source: Field Survey, 2022

Note. Cumulative mean: need = 3.44; performance = 2.02.

Table 3

Mean and Standard Deviations of Responses on Proficiency Skills Needed for Instructional Purposes: Word-Processing Skills

Cluster 2: Word Processing Skills			Level of Need	Level of Need		Level of performance	Level of performance
S/N	ITEM STATEMENTS	N	XN	Std. Deviation		XP	Std. Deviation
35	Ability to add text to documents	157	3.7452	.54189	3.7580		.52381
36	Ability to enter text	157	3.7962	.40413	3.5732		.67181
37	Ability to format text: font, style, size, and color	157	3.6688	.57052	2.5350		.86624
38	Ability to adjust line spacing	157	3.6688	.57052	2.1911		.97490
39	Ability to insert and format WordArt	157	3.6561	.59607	1.7898		.89178
40	Ability to insert and format clip art or picture file	157	3.6433	.62031	1.8025		.90893
41	Ability to modify the text wrap of an object	157	3.6306	.64337	1.7898		.91309
42	Ability to draw and format shapes	157	3.6752	.56859	1.7771		.86676
43	Ability to scale, move, and rotate objects	157	3.7389	.50822	1.7834		.89384
44	Ability to insert a simple page border	157	3.6433	.59928	1.7707		.88341

Cluster 2: Word Processing Skills			Level of Need	Level of Need	Level of performance	Level of performance
45	Ability to spell check a document	157	3.6624	.63603	2.3057	1.17486
46	Ability to print preview	157	3.9682	.17615	2.5732	1.09897
47	Ability to print a document	157	3.9554	.20705	2.2293	1.06140
48	Ability to cut, copy, and paste a selection	157	3.9236	.31094	3.7325	.66393
49	Ability to copy formatting from a selection	157	3.6752	.59070	2.1720	1.06926
50	Ability to create graphic organizer	157	3.7197	.55278	2.4076	.77588
51	Ability to bookmark a location in a document	157	3.9618	.19233	1.9363	.98503
52	Ability to insert headers and footers	157	3.9618	.19233	1.8535	.93243
53	Ability to insert date and page numbers	157	3.9618	.19233	1.7771	.86676
54	Ability to adjust character and paragraph spacing	157	3.9682	.17615	1.9682	1.02795
55	Ability to select desired cells to be printed	157	3.9490	.27260	1.8854	.89849
56	Ability to create hyperlink to bookmarked location	157	3.9490	.24797	1.8471	.86355
57	Ability to group and align objects	157	3.8408	.48714	1.7707	.89781
58	Ability to adjust page setup: margins, section breaks	157	3.7516	.60612	1.8025	.87295
59	Ability to use, modify, and create styles	157	3.6433	.74259	1.8089	.84074
60	Ability to use mail merge to create a form or letter	157	3.8089	.52052	1.8790	.87230
61	Ability to import chart data into Microsoft Word	157	3.7452	.61919	1.7834	.82678
62	Ability to create a table of contents	157	3.6943	.71309	1.8089	.90677
63	Ability to format text into columns	157	3.6688	.70154	1.7834	.87938
64	Ability to insert and format tables	157	3.6115	.82158	2.1847	1.00525
65	Ability to insert pictures data into Microsoft Word	157	3.6051	.76592	2.1783	1.05310
66	Ability to insert clip Arts into Microsoft Word	157	3.6051	.76592	2.1783	1.05310
67	Ability to take and insert Screenshots into Microsoft Word	157	3.6242	.67381	2.1783	1.05310
Table 2.c: Mean and standard deviation of responses of Agricultural education Lecturers and Technologist on the proficiency skills needed by Agricultural Education Lecturers' for instructional purposes (Application of spreadsheet skills)						

Source: Field Survey, 2022 ; Note. Cumulative mean: need = 3.76; performance = 2.14.

Table 4

Means and Standard Deviations of Responses on Proficiency Skills Needed for Instructional Purposes: Spreadsheet Skills

Cluster 3: Spreadsheet processing skills			Level of Need	Level of Need	Level of performance	Level of performance
S/N	ITEM STATEMENTS	N	XN	Std. Deviation	XP	Std. Deviation
68	Ability to define basic spread sheet terminology	157	3.6752	.69075	1.7516	.83709
69	Ability to identify a cell reference	157	3.6815	.67973	1.7516	.83709
70	Ability to enter, edit, or delete data into a cell	157	3.6624	.71211	2.2484	1.05403
71	Ability to select a cell or a range of cells	157	3.6497	.72383	2.2293	1.07341
72	Ability to modify column width and row height	157	3.6688	.66399	2.1019	1.07527
73	Ability to merge and center data	157	3.7134	.71657	2.6688	1.05847
74	Ability to apply borderlines	157	3.7134	.71657	2.6943	1.04183
75	Ability to apply number formats to data	157	3.7070	.73608	2.6943	1.04183
76	Ability to alter the number of decimal places	157	3.7389	.63191	1.8089	.87804
77	Ability to calculate the total number using AutoSum	157	3.5860	.77662	2.1911	1.17197
78	Ability to sort data alphabetically or numerically graph data	157	3.5860	.77662	2.1911	1.17197
79	Ability to format a graph to alter its appearance	157	3.7134	.55529	1.6815	.86260
80	Ability to scale, move, and rotate objects	156	3.5705	.68262	2.2102	1.17141
81	Ability to insert and delete columns or rows	157	3.9554	.20705	3.5159	.82123
82	Ability to view a worksheet using the sheet tabs	157	3.9618	.19233	3.6561	.59607
83	Ability to print a workbook or worksheet	157	3.9618	.19233	3.6561	.59607
84	Ability to copy formatting from a cell to another	157	3.7070	.49693	1.8790	.81138
85	Ability to cut, copy and paste a selection of cells	157	3.7070	.49693	3.8471	.37835
86	Ability to calculate data using formulas	157	3.9554	.20705	1.8471	.87827
87	Ability to use statistical functions	157	3.9554	.20705	1.8471	.87827
88	Ability to format a cell using conditional formatting	157	3.9490	.22061	1.8280	.95527
89	Ability to apply an auto format to a selection of cells	157	3.5796	.72614	2.3376	.91675
90	Ability to insert or delete worksheets	157	3.9618	.19233	3.8471	.41084
91	Ability to copy a worksheet	157	3.9682	.17615	3.8471	.41084
92	Ability to rename or color a sheet tab	157	3.9682	.17615	2.2166	1.15647

	Cluster 3: Spreadsheet processing skills		Level of Need	Level of Need	Level of performance	Level of performance
93	Ability to customize print settings	157	3.9682	.17615	1.8790	.94970

Source: Field Survey, 2022

Note. Cumulative mean: need = 3.77; performance = 2.47. N = 157.

Table 5

Summary Need-Gap Analysis of Mean Ratings on Proficiency Skills Needed for Instructional Purposes

S/N	CLUSTERS	ITEMS	Xn	Xp	NG Xn-Xp	Decision
1.	A1	General knowledge in ICT	3.44	2.02	1.41	Needed
2.	A2	Application of Word processing skills	3.76	2.14	1.61	Needed
3.	A3	Application of spreadsheet skills	3.77	2.47	1.30	Needed
	Grand Mean		3.66	2.21	1.44	Needed

Note. Xn = mean rating of need; Xp = mean rating of performance. Source: Field Survey, 2022.

As shown in Table 5, the need-gap values for the three clusters ranged from 1.30 to 1.61 and were all positive. This indicates that agricultural education lecturers in tertiary institutions needed proficiency skills for instructional purposes across all three clusters in the utilisation of information and communication technology for pedagogical effectiveness in tertiary institutions of South-West, Nigeria

The three clusters comprised 93 elements. Eighty-nine of the 93 elements recorded positive need-gap values ranging from 0.11 to 2.20, indicating that agricultural education lecturers in tertiary institutions in South-West Nigeria required proficiency training in those elements. Four elements – items 11 (−0.26), 18 (−0.00), 35 (−0.01) and 48 (−0.01) – recorded negative need-gap values, indicating that training was not required for those items.

Discussion of Findings

The high share of the ICT facilities deemed necessary speaks of the practicality of agricultural education. In particular, external storage devices, interactive boards, multimedia projectors and statistical software become very relevant in laboratories, data analysis from field work, description of agricultural processes and providing visual material. The findings are consistent with those of related studies that identified the use of ICT tools in the instructional process. One notable study conducted by Yushau & Nannim in 2020 revealed that lecturers utilize electronic whiteboards/Smart Boards (including the Triumph Board and Genee Touch), as well as Microsoft Word, PowerPoint, Excel, external devices, the internet, PDFs, and graphic software for teaching purposes in the classroom. The low rating of fax machines, satellite technology and joysticks reflects the obsolescence of the former and the inefficiency of the latter in terms of teaching in the modern tertiary classroom. This finding is consistent with the lists of necessary ICTs for educational purposes compiled earlier (Akachukwu and Edikpa, 2018; Onugha, 2009).

Consistently positive gaps in general knowledge, as well as in word processing and spreadsheets skill clusters, indicate that the lecturers in the field of agricultural education need competencies that go beyond computer literacy. Contemporary lecturing includes such tasks as creating digital content, working with data from students, creating interactive presentations and digital assessment of the progress of learning process. The finding suggests that agricultural education lectures require competences beyond basic computer literacy. Similar observations indicate that productivity and presentation skills are essential, because modern teaching requires lecturers to design, analyse and present digital learning materials (Ajie-Uche et al., 2018; Okoye and Ugwugwo, 2021). The findings are in conformity with some of the general teachers' competencies and skills required in the use of ICT facilities and tools as outlined by the UNESCO (2018). The results are consistent with a study by Igbongidi (2018) that revealed that all the identified fifty three skills (53) on computer appreciation, word processing, internet and data processing are needed by business studies teachers in Bayelsa State.

The results of this study were also in agreement with Akinnagbe and Baiyeri's (2011) analysis of the training needs of lecturers for improving their ICT skills in the Faculty of Agriculture at the University of Nigeria, Nsukka, where the authors discovered that the lecturers lacked proficiency in the creation of spreadsheets, data analysis using software, and slide preparation and presentations

TPACK framework can provide an explanation of the significance of the mentioned gaps: without sufficient technological knowledge (TK) and technological pedagogical knowledge (TPK), the lecturers would not be able to utilise all opportunities provided by modern technologies. Mishra and Koehler (2006) asserted that TPACK is a crucial framework for understanding how pedagogy, technology, and content interact to enhance the efficacy,

efficiency, and engagement of learning. They emphasized the need to explore design-based approaches for integrating ICT into African classrooms. For this integration to be successful, teachers must be adaptable and able to acquire knowledge about the school, students, and local context, in addition to utilizing available resources and tools.

Nonetheless, the few areas where training was not required (especially basic knowledge about PowerPoint and basic manipulation of text) indicate that most of the lecturers are well versed in basic presentation techniques and text manipulation, probably due to the needs arising from daily work in administration and instruction. In light of this, professional development programmes may consider developing the skills in more complex areas like administration of the learning management system, complex spreadsheet modelling, multimedia production, and design of collaborative ICT activities.

Conclusion

From the results of the study, it has been revealed that a very large number of ICT facilities are considered necessary for the instructional process of agricultural education. In addition, there are some proficiency deficiencies in terms of general ICT knowledge, word processing and spreadsheets. These deficiencies clearly indicate the need for further training in order to enable lecturers to use technology in teaching and learning process effectively. This will improve the preparedness of tertiary agricultural education programmes in preparing graduates for technological agriculture.

Recommendations

Based on the research findings, the following recommendations were made:

- i. Continuous professional development programmes, which are to be designed and developed by tertiary institutions in conjunction with relevant professional bodies, are needed to cater to the ICT competence deficiency highlighted by this study.
- ii. Procurement, maintenance and equal allocation of the ICT facilities perceived as necessary for respondents by the government at federal and state levels as well as institution management are important.
- iii. The agriculture education syllabus should be revised to incorporate the use of ICT in such a way that ICT literacy skills of both lecturers and learners can be developed.

Further studies using mixed methods and samples drawn from multiple regions should be conducted.

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Comparative Effects of Virtual Reality and Traditional Video-Based Learning on Immediate Achievement and Concept Retention in Senior Secondary School Physics in Rivers State, Nigeria

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Abstract

This study compared VR-based and video-based learning in relation to students' immediate achievement and four-week delayed concept retention in Senior Secondary School Physics, focusing on electromagnetic-field concepts. A quasi-experimental pre-test/post-test non-equivalent group design was adopted. The participants were 80 Senior Secondary 2 Physics students from two purposively selected secondary schools in Rivers State, Nigeria. Four intact classes were allocated to either a VR-based learning condition or a video-based learning condition. Both groups studied equivalent content for four weeks. Data were collected using a 40-item Physics Concept Retention Test administered as a pre-test, immediate post-test and four-week delayed post-test. The data were analysed using descriptive statistics and Analysis of Covariance, with pre-test scores serving as the covariate. Students in the VR-based learning group obtained higher mean scores than those in the video-based learning group on both the immediate and delayed post-tests. The instructional method-by-gender interaction on delayed concept-retention scores was not statistically significant. The findings provide preliminary evidence that interactive three-dimensional learning may support the study of abstract and spatially demanding Physics concepts. However, the use of purposively selected schools and intact classes limits causal and generalisable conclusions. Further research involving larger samples, more schools, monitored exposure and longer follow-up periods is recommended.

Keywords: Virtual reality, video-based learning, immediate achievement, concept retention, Physics education, electromagnetic fields.

Introduction

The rapid development of digital technologies has created new possibilities for improving the teaching and learning of Science, Technology, Engineering, and Mathematics (STEM) subjects. Educational technologies can support the visualisation and exploration of concepts that are difficult to observe directly, thereby complementing conventional classroom instruction. This is particularly relevant in Nigerian schools, where inadequate laboratory facilities and limited

instructional resources may constrain students' opportunities to engage with practical and abstract scientific concepts (Ajemba, 2024; Oginni, Awobodu, and Olusegun, 2025). Recent initiatives have similarly advocated AI-driven approaches to widen access to STEM education for underserved learners (Nweje, 2026).

Virtual Reality (VR) is an emerging technology that may help address some of these challenges. VR provides three-dimensional environments in which learners can explore and interact with simulated objects, processes and phenomena. Its immersive and interactive features may help learners develop clearer mental representations of concepts that are spatially complex or difficult to observe directly (Makransky and Petersen, 2021; Pottle, 2019). In Physics, these affordances may be particularly useful for topics involving invisible forces, dynamic processes and spatial relationships. VR has similarly been integrated with peer-assessment strategies to support science learning in other subject domains (Chang, Hsu, and Jong, 2020), and such tools are becoming increasingly integrated into mainstream classroom instruction (Oigara, 2018). Related immersive technologies such as augmented reality have also been associated with a range of educational benefits (Diegmann, Schmidt-Kraepelin, van den Eynden, and Basten, 2015; Lytvynova and Soroko, 2023), and a growing body of work associates VR and AR tools with improved student performance across STEM fields more broadly (Pireva Nuci and Shatri, 2026).

Electromagnetic-field concepts present notable learning difficulties because electric and magnetic fields cannot be observed directly in the same way as visible physical objects. Students are expected to understand field direction, distribution, intensity, magnetic field lines, solenoids, current direction and electromagnetic induction. These concepts require learners to construct mental representations of relationships that are not readily visible through ordinary classroom observation. Where laboratory resources are limited, the difficulty of providing meaningful learning experiences may be increased (Ajemba, 2024; Oginni et al., 2025).

Video-based learning offers a relatively accessible means of presenting demonstrations, animations and explanations of Physics phenomena. It requires fewer technological resources than some immersive technologies and allows students to revisit instructional materials. However, conventional two-dimensional videos generally provide limited opportunities for learners to manipulate phenomena or explore spatial relationships from different perspectives. VR, in contrast, may provide a more interactive environment in which students can examine simulated field patterns, manipulate selected variables and observe corresponding changes. These features may support active engagement and conceptual understanding (Makransky and Petersen, 2021).

However, the potential value of VR should not be judged solely by students' immediate performance after instruction. A higher post-test score may indicate successful learning at the end of an intervention without demonstrating that the knowledge has been retained. Delayed

assessment therefore provides additional evidence of whether learning is maintained beyond the immediate instructional experience. Comparing immediate achievement with delayed concept retention can consequently provide a more comprehensive assessment of technology-supported Physics instruction.

Gender is another factor that may warrant consideration. Students may differ in their previous experiences with digital technologies, confidence, engagement and learning opportunities. These differences could potentially influence their responses to technology-supported instruction. Examining the interaction between instructional method and gender may therefore indicate whether the effectiveness of the instructional approaches varies across male and female students. Any claims about gender differences should, however, be supported by relevant gender-and-technology or Physics-education literature.

Despite increasing interest in immersive learning, empirical evidence comparing VR and video-based learning using both immediate and delayed measures remains limited, particularly in Nigerian secondary-school Physics. Evidence is especially limited for electromagnetic-field concepts, where students must understand abstract and spatially demanding relationships. This study therefore compared VR-based and video-based learning in relation to students' immediate achievement and four-week delayed concept retention in Senior Secondary School Physics in Rivers State, Nigeria. It also examined whether instructional method interacted with gender in relation to delayed concept-retention performance.

Statement of the Problem

Physics is important to scientific and technological development, yet many secondary-school students experience difficulty understanding abstract concepts involving invisible forces, spatial relationships, and dynamic processes. Electromagnetic-field concepts are particularly challenging because their patterns and interactions cannot be directly observed. Inadequate laboratory facilities and instructional resources may further limit opportunities for students to develop meaningful understanding of such concepts (Ajemba, 2024; Oginni et al., 2025). These constraints carry implications extending across STEM-dependent sectors such as agriculture and health (Olatunji and Akinola, 2023).

Video-based learning provides an accessible means of presenting demonstrations and visual explanations, but its two-dimensional format may offer limited opportunities for learners to interact with complex spatial relationships. VR provides a more immersive alternative by allowing students to explore and manipulate three-dimensional representations of physical phenomena. Although previous studies have reported promising learning outcomes associated with VR, evidence comparing VR directly with video-based learning in Nigerian secondary-school Physics remains limited. Furthermore, immediate post-test performance does not necessarily demonstrate that students retain what they have learned. There is therefore a need to determine whether VR and video-based learning differ in their effects on both immediate

achievement and delayed concept retention. It is also important to establish whether the effectiveness of these instructional approaches differs according to gender.

The problem addressed by this study, therefore, was the limited empirical evidence on the comparative effectiveness of VR-based and video-based learning for immediate achievement and delayed retention of electromagnetic-field concepts among Senior Secondary School Physics students in Rivers State. The study consequently compared the two instructional approaches and examined their interaction with gender on students' delayed concept-retention performance.

Purpose of the Study

The purpose of this study was to compare the outcomes associated with VR-based and video-based learning on students' immediate achievement and delayed concept retention in Senior Secondary School Physics, with emphasis on electromagnetic-field concepts in Rivers State.

Specifically, the study sought to:

1. compare the immediate achievement scores of students exposed to VR-based and video-based learning;
2. compare the delayed concept-retention scores of students exposed to VR-based and video-based learning; and
3. determine the interaction effect of instructional method and gender on students' delayed concept-retention scores.

Research Questions

1. What difference exists in the mean immediate achievement scores of students exposed to VR-based and video-based learning?
2. What difference exists in the mean delayed concept-retention scores of students exposed to VR-based and video-based learning?
3. What interaction effect exists between instructional method and gender on students' delayed concept-retention scores?

Research Hypotheses

The following null hypotheses were tested at the 0.05 level of significance:

1. There is no significant difference in the mean immediate achievement scores of students exposed to VR-based and video-based learning.
2. There is no significant difference in the mean delayed concept-retention scores of students exposed to VR-based and video-based learning.
3. There is no significant interaction effect between instructional method and gender on students' delayed concept-retention scores.

Materials and Methods

The study adopted a quasi-experimental pre-test/post-test non-equivalent group design involving 80 Senior Secondary 2 (SS2) Physics students from two purposively selected secondary schools in Obio/Akpor Local Government Area, Rivers State, Nigeria, during the 2025/2026 academic session. Four intact classes were assigned to VR-based and video-based learning conditions, with 40 students in each group. The schools were selected based on the availability of digital-learning facilities. Students were not individually randomised.

The VR group learned through three-dimensional simulations of magnetic-field lines, solenoid behaviour, current direction and electromagnetic induction, while the video group used two-dimensional instructional videos covering the same content. Both conditions were standardised in curriculum content, objectives and instructional duration and implemented for four weeks.

Data were collected using a 40-item Physics Concept Retention Test (PCRT), validated by experts and pilot-tested, with a KR-20 reliability coefficient of 0.70. The instrument was administered as a pre-test, immediate post-test and four-week delayed post-test.

Data were analysed using means, standard deviations and Analysis of Covariance (ANCOVA), with pre-test scores as the covariate. Separate ANCOVA models examined immediate achievement and delayed retention, while the gender model included instructional method, gender and their interaction. ANCOVA assumptions were examined before analysis. Partial eta squared was used to estimate effect sizes, and unadjusted Cohen's *d* was calculated where appropriate. Hypotheses were tested at the 0.05 significance level.

Results and Analysis

Research Question 1: What difference exists in the mean immediate achievement scores of students exposed to VR-based and video-based learning?

Table 1: Descriptive Statistics for Immediate Achievement Scores by Instructional Method

Instructional Method	N	Mean	Std. Deviation
VR-based learning	40	78.45	6.12
Video-based learning	40	64.20	7.35

Table 1 shows that students exposed to VR-based learning obtained a higher mean immediate-achievement score ($M = 78.45$, $SD = 6.12$) than those exposed to video-based learning ($M = 64.20$, $SD = 7.35$), representing an unadjusted mean difference of 14.25 points in favour of the VR group.

Table 2: ANCOVA Summary of Immediate Achievement Scores by Instructional Method

Source	Type III SS	df	Mean Square	F	p
Pre-test	124.50	1	124.50	2.90	.092
Instructional method	3,842.15	1	3,842.15	89.68	< .001
Error	3,300.20	77	42.86	—	—
Corrected total	7,266.85	79	—	—	—

The ANCOVA revealed a statistically significant difference in immediate-achievement scores, $F(1, 77) = 89.68$, $p < 0.001$, partial $\eta^2 = 0.538$; H_{01} was therefore rejected. Students exposed to VR-based learning performed significantly better than those exposed to video-based learning. As both conditions were implemented in both schools, school confounding was limited, though intact classes mean pre-existing class-level differences cannot be entirely ruled out.

Research Question 2: What difference exists in the mean delayed concept-retention scores of students exposed to VR-based and video-based learning?

Table 3: Descriptive Statistics for Delayed Concept-Retention Scores

Instructional Method	N	Mean	Std. Deviation
VR-based learning	40	75.10	6.85
Video-based learning	40	58.45	8.12

Table 3 shows that students exposed to VR-based learning obtained a higher mean four-week delayed concept-retention score ($M = 75.10$, $SD = 6.85$) than those exposed to video-based learning ($M = 58.45$, $SD = 8.12$). The observed unadjusted mean difference was 16.65 points in favour of the VR-based learning group.

Table 4: ANCOVA Summary of Four-Week Delayed Concept-Retention Scores by Instructional Method

Source	Type III SS	df	Mean Square	F	p
Pre-test	98.20	1	98.20	2.45	.121
Instructional method	4,215.30	1	4,215.30	105.09	< .001
Error	3,088.60	77	40.11	—	—
Corrected total	7,402.10	79	—	—	—

The ANCOVA revealed a statistically significant difference in four-week delayed concept-retention scores, $F(1, 77) = 105.09$, $p < 0.001$, partial $\eta^2 = 0.577$; H_{02} was therefore rejected. Students exposed to VR-based learning obtained significantly higher delayed-test scores than those exposed to video-based learning, indicating the difference persisted four weeks after the intervention. As intact classes were used, pre-existing class-level differences cannot be completely ruled out.

Research Question 3: What interaction effect exists between instructional method and gender on students' delayed concept-retention scores?

Table 5: Mean Delayed Concept-Retention Scores by Instructional Method and Gender

Instructional Method	Gender	N	Mean	Std. Deviation
VR-based learning	Male	20	75.80	6.20
VR-based learning	Female	20	74.40	7.50
Video-based learning	Male	20	59.20	7.90
Video-based learning	Female	20	57.70	8.40

Table 5 shows that both male and female students exposed to VR-based learning obtained higher mean delayed concept-retention scores than their counterparts exposed to video-based learning. The differences between male and female students within each instructional condition were relatively small. An inferential analysis was therefore conducted to determine whether the interaction between instructional method and gender was statistically significant.

Table 6: ANCOVA of Four-Week Delayed Concept-Retention Scores by Instructional Method, Gender, and Their Interaction.

Source	Type III SS	df	Mean Square	F	p	Partial η^2
Pre-test	98.20	1	98.20	2.40	.125	.031
Instructional method	4,210.50	1	4,210.50	102.94	< .001	.579
Gender	18.20	1	18.20	0.44	.507	.006
Instructional method $\times$ Gender	2.50	1	2.50	0.06	.805	.001
Error	3,067.90	75	40.91	—	—	—
Corrected Total	7,397.30	79	—	—	—	—

Table 6 shows that the pre-test covariate was not statistically significant, $F(1, 75) = 2.40$, $p = 0.125$, partial $\eta^2 = 0.031$. However, instructional method had a statistically significant effect on students' four-week delayed concept-retention scores, $F(1, 75) = 102.94$, $p < 0.001$, partial $\eta^2 = 0.579$. The large effect size indicates that instructional method was strongly associated with differences in delayed concept-retention performance, with students exposed to VR-based learning obtaining higher mean scores than those exposed to video-based learning.

The main effect of gender was not statistically significant, $F(1, 75) = 0.44$, $p = 0.507$, partial $\eta^2 = 0.006$, indicating that delayed concept-retention scores did not differ significantly between male and female students after controlling for the other variables in the model. Similarly, the instructional method $\times$ gender interaction was not statistically significant, $F(1, 75) = 0.06$, $p = 0.805$, partial $\eta^2 = 0.001$. Therefore, the null hypothesis was not rejected. The finding indicates that the association between instructional method and delayed concept-retention performance did not vary significantly by gender within the study sample. However, this result should be interpreted cautiously and should not be taken as evidence that the two instructional methods are equally effective across genders in the wider population.

Discussion of Findings

Immediate Achievement

In relation to Research Question 1, the findings showed that students exposed to VR-based learning achieved significantly higher immediate post-test scores than those exposed to video-based learning. This difference may be associated with the interactive and three-dimensional features of the VR environment, which enabled students to visualise and manipulate representations of electromagnetic phenomena. Such experiences may have contributed to clearer mental representations, although mental representations were not directly measured in this study. The finding is consistent with the view that immersive and interactive learning environments may support engagement with abstract and spatially demanding concepts (Makransky and Petersen, 2021). However, because the study used intact classes, the result should be interpreted as a difference associated with the instructional conditions rather than definitive evidence that VR alone produced the higher achievement.

Delayed Concept Retention

In relation to Research Question 2, students exposed to VR-based learning obtained significantly higher scores on the four-week delayed concept-retention test than those exposed to video-based learning. Although performance declined in both groups after the immediate post-test, the VR-based learning group recorded the higher delayed-test mean. This suggests that the difference associated with the VR condition remained evident four weeks after the intervention. The finding may be related to the opportunity provided by VR for learners to interact with and examine three-dimensional representations of otherwise abstract electromagnetic phenomena. Nevertheless, the result represents performance on a single four-week delayed assessment and should not be interpreted as evidence of permanent or long-term retention.

Gender Interaction

In relation to Research Question 3, the findings showed no statistically significant interaction between instructional method and gender in relation to delayed concept-retention scores. Male and female students exposed to VR-based learning both obtained higher mean scores than their counterparts in the video-based learning group, while the differences between male and female students within each instructional condition were relatively small. This indicates that the study did not detect a significant gender-based difference in the relationship between instructional method and delayed concept retention. However, the finding should be interpreted cautiously because each gender-by-instructional-condition subgroup contained only 20 students. The non-significant interaction should therefore not be interpreted as proof that VR is equally effective across genders in the wider population.

Conclusion

This study compared VR-based and video-based learning in relation to students' immediate achievement and four-week delayed concept-retention performance in Senior Secondary School Physics, focusing on electromagnetic-field concepts. Students in the VR-based learning group obtained higher scores on both the immediate and delayed post-tests than those in the video-based learning group, indicating that the difference associated with the VR condition remained evident four weeks after the intervention.

The findings provide preliminary evidence that interactive three-dimensional learning may support students' understanding of abstract and spatially demanding Physics concepts. Nevertheless, the use of purposively selected schools and intact classes means that pre-existing school- and class-level differences cannot be completely excluded. The two instructional packages may also have differed in interactivity, learner control, feedback, immersion, novelty and opportunities for manipulation. The results should therefore be interpreted as differences associated with the instructional conditions, not as definitive proof that VR alone caused the observed outcomes.

The study did not detect a statistically significant interaction between instructional method and gender in relation to delayed concept-retention performance. This finding remains preliminary because only 20 students were included in each gender-by-method subgroup. The focus on one Physics topic, the four-week follow-up period, the marginal reliability of the assessment instrument and the limited treatment-fidelity information further restrict the generalisability of the findings.

Overall, VR-based learning may serve as a useful complement to video-based learning when teaching electromagnetic-field concepts. Wider implementation should begin with carefully evaluated pilot programmes supported by teacher training, adequate infrastructure and further research involving larger samples, more schools and classes, monitored exposure, stronger assessment procedures and longer follow-up periods.

Recommendations

Based on the findings and limitations of the study, the following recommendations are made:

1. VR should be considered particularly for Physics topics involving spatial relationships, invisible phenomena, simulation, and processes that are difficult to demonstrate using conventional resources.
2. Teachers should combine video-based explanations with VR-based exploration where appropriate, allowing students to benefit from both accessible visual instruction and interactive three-dimensional experiences.
3. Physics teachers should receive training in VR-supported lesson planning, learner guidance, assessment, classroom management, and basic technical troubleshooting.

4. Schools and education authorities should provide the necessary digital infrastructure, including suitable devices, electricity, maintenance, offline resources, and reliable access to instructional content.
5. Future studies should include more schools and intact classes in each instructional condition, larger samples, stronger treatment-fidelity procedures, monitored exposure and time-on-task, and longer delayed assessments to provide stronger evidence of retention and transfer.
6. Future research should further examine whether learner characteristics, including gender, prior digital experience, technology confidence, and learning readiness, influence students' responses to VR-based instruction.

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Secondary School Teachers' Knowledge and Utilisation of Agro-Digital Technologies for Perceived Agripreneurship Competency Development in Odogbolu Local Government Area, Ogun State, Nigeria

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Abstract

This study assessed secondary school agricultural science teachers' knowledge and utilisation of agro-digital technologies, and teachers' perceived extent to which such technologies foster agripreneurship competencies among students in Odogbolu Local Government Area (LGA), Ogun State, Nigeria. Anchored on the Technological Pedagogical Content Knowledge (TPACK) framework and the Technology Acceptance Model (TAM), the study adopted a descriptive survey design with correlational elements. A proportionate stratified random sample of agricultural science teachers was drawn across public secondary schools in the LGA; 172 copies of a validated instrument, the Agro-Digital Technologies Knowledge, Utilisation, and Agripreneurship Competencies Questionnaire (ADTKUACQ), were administered, of which 150 were valid for analysis (87.2% response rate). Descriptive statistics and independent samples t-test, Pearson correlation, and one-way ANOVA were used for analysis. Findings revealed generally low knowledge (grand mean = 2.13) and very low utilisation (grand mean = 1.84) of agro-digital technologies among teachers, with correspondingly low perceived development of agripreneurship competencies among students (grand mean = 2.16). Infrastructural deficits, particularly unreliable electricity and poor internet connectivity, alongside inadequate training, emerged as the most severe barriers (grand mean = 3.17). Teachers strongly endorsed systemic interventions, especially in-service training and ICT infrastructure provision (grand mean = 3.45). No statistically significant differences were found across gender, teaching experience, or educational qualification, indicating that the observed

deficits are systemic rather than demographic in nature. The study recommends coordinated investment in rural school infrastructure, curriculum reform, and sustained teacher professional development to strengthen agro-digital integration and youth agripreneurship outcomes.

Keywords: agro-digital technologies, perceived agripreneurship competencies, secondary school teachers, TPACK, Technology Acceptance Model, Odogbolu, Ogun State

Introduction

Global agriculture faces mounting pressure to meet rising food demand amid climate change, population growth, and resource constraints, driving increased reliance on digital innovations such as precision farming, artificial intelligence, drones, and mobile advisory platforms (FAO, 2024). In Sub-Saharan Africa, where agriculture remains central to livelihoods and GDP, digital tools have shown potential to raise yields and improve market access, although adoption remains constrained by infrastructural and educational barriers (Choruma et al., 2024).

In Nigeria, agriculture contributes substantially to GDP and employment, yet youth unemployment remains critical, with tens of millions of young people jobless (Eboesomi, 2025). Agripreneurship – the entrepreneurial application of agricultural knowledge to build innovative, sustainable enterprises – offers a viable pathway to youth economic empowerment (Adeyanju et al., 2023; Mhlana, 2023). Secondary school agricultural science education represents a strategic entry point for cultivating these competencies, yet Nigerian secondary school agricultural science curricula often rely on outdated pedagogies that fail to engage students or adequately prepare them for a digitised agribusiness environment (Bamiro et al., 2024; Nwakile, 2020).

While Ogun State has pioneered several digital agriculture initiatives – including the Ogun State Farmers Information Management System (OGFIMS), the AgriConnect programme and the AKILIMO advisory application (CGIAR, 2025; FMCIDE, 2025) – the extent to which these innovations have permeated secondary school instruction remains unclear. In Odogbolu LGA specifically, despite rich agricultural potential in crops such as cassava, maize, and oil palm, digital resources appear underutilised in classroom settings. This study therefore examines secondary school teachers' knowledge and use of agro-digital technologies and their perceived role in developing agripreneurship competencies among students in Odogbolu LGA.

Conceptual Clarification of Key Constructs

For the purposes of this study, agro-digital technologies are operationally defined as digital tools, platforms, and applications – including mobile apps, GIS/GPS systems, drones, IoT sensors, artificial intelligence tools, blockchain platforms, e-learning resources and digital financial tools – that can be applied to agricultural production, extension, marketing, or agricultural science instruction. Agripreneurship competencies are operationally defined as the entrepreneurial knowledge, skills, and dispositions required to identify, plan, and manage viable agriculture-

based enterprises, encompassing innovation, business planning, risk management, digital marketing, value chain integration, and related capacities. Because this study relies on teachers' self-reported assessments rather than direct measurement of student outcomes (e.g., business plans, test scores, or enterprise simulations), the competency construct is treated throughout as teachers' perceived development of these competencies among their students, not as an objectively verified outcome.

Objectives of the Study

The general purpose of this study was to assess secondary school agricultural science teachers' knowledge and utilisation of agro-digital technologies, and their perceived contribution to students' agripreneurship competency development, in Odogbolu LGA, Ogun State. Specifically, the study sought to:

- i. determine the level of knowledge of agro-digital technologies among agricultural science teachers in Odogbolu LGA;
- ii. assess the extent of utilisation of agro-digital technologies in the teaching of agricultural science;
- iii. examine teachers' perceived development of agripreneurship competencies among students through the use of agro-digital technologies;
- iv. identify barriers to teachers' adoption of agro-digital technologies; and
- v. determine strategies for improving teachers' knowledge and utilisation of agro-digital technologies.

Hypotheses

The following null hypotheses were formulated to guide the study, corresponding to Objectives 1–3:

H₀1: There is no significant difference in agro-digital technology knowledge between male and female teachers.

H₀2: There is no significant relationship between years of teaching experience and agro-digital technology utilisation.

H₀3: There is no significant influence of educational qualification on teachers' perceived agripreneurship competency development.

Methodology

The study employed a descriptive survey design with correlational elements, conducted in Odogbolu Local Government Area (LGA), Ogun State, a predominantly agrarian area cultivating cassava, maize, oil palm, and cash crops. The target population comprised all agricultural science teachers in public secondary schools in the LGA. Private secondary schools were excluded from the sampling frame because agricultural science is not offered as a distinct subject in the private

schools within the LGA at the time of data collection; agricultural content in these schools is typically subsumed under general basic science, making them unsuitable for a study specifically assessing agricultural science teachers.

Using records obtained from the Ogun State Ministry of Education (Odogbolu LGA education office), the population of agricultural science teachers across public secondary schools in the LGA was identified. A proportionate stratified random sampling technique was adopted, with schools serving as strata, to ensure fair representation of teachers across the LGA's public secondary schools. A total of 172 copies of the questionnaire were administered to eligible agricultural science teachers. Of these, 150 were correctly completed and returned, yielding a valid response rate of 87.2%. The 22 excluded responses comprised questionnaires that were not returned ($n = 14$) and those returned with substantial missing data on key sections, rendering them unsuitable for analysis ($n = 8$). All subsequent analyses were based on the 150 valid responses.

Data were collected using the researcher-developed Agro-Digital Technologies Knowledge, Utilisation, and Agripreneurship Competencies Questionnaire (ADTKUACQ), comprising sections on demographics, knowledge (25 items), utilisation (20 items), perceived competency development (20 items), barriers (20 items), and improvement strategies (20 items), rated on 4-point Likert scales. Content and construct validity were established through expert review by three specialists in agricultural education and educational measurement, followed by a pilot test involving 20 agricultural science teachers in a neighbouring LGA (Ijebu North), who were excluded from the main study. Cronbach's alpha reliability coefficients obtained from the pilot data were: knowledge subscale ($\alpha = 0.84$), utilisation subscale ($\alpha = 0.87$), competency subscale ($\alpha = 0.81$), barriers subscale ($\alpha = 0.79$), and strategies subscale ($\alpha = 0.83$), all exceeding the acceptable threshold of 0.70 (Taber, 2018).

Ethical clearance for the study was obtained from the Research Ethics Committee of the Department of Agricultural Science Education, Tai Solarin Federal University of Education, prior to data collection. Participation was voluntary, and informed consent was obtained from all respondents after they were briefed on the purpose of the study and assured of confidentiality and anonymity of their responses. Data collection was carried out over a six-week period between February and April, 2026.

Data were analysed descriptively (means, standard deviations) and inferentially (independent samples t-test, Pearson correlation, one-way ANOVA) using SPSS version 26. Given that the 150 respondents were drawn through stratified random sampling from a larger population of agricultural science teachers in the LGA rather than constituting a full census, the use of inferential statistics is methodologically appropriate for generalising findings to the broader population of agricultural science teachers in Odogbolu LGA. Mean scores were interpreted as High/Very High (≥ 3.50), Moderate (2.50–3.49), or Low (< 2.50) for the

knowledge, utilisation, and competency scales. For the barriers and strategies scales, the same 4-point Likert benchmark was applied, with mean scores of ≥ 3.50 interpreted as “Strongly Agreed,” 2.50–3.49 as “Agreed,” 1.50–2.49 as “Disagreed,” and below 1.50 as “Strongly Disagreed.”

Results

Socio-Demographic Characteristics of Respondents

Of the 172 questionnaires administered, 150 were correctly completed and returned, giving a valid response rate of 87.2%.

Table 1: Socio-Demographic Characteristics of Respondents (N = 150)

Variable	Category	Frequency	Percentage (%)
Gender	Male	93	62.0
	Female	57	38.0
	Total	150	100.0
Age Group	20–29 years	21	14.0
	30–39 years	57	38.0
	40–49 years	48	32.0
	50–59 years	18	12.0
	60 years and above	6	4.0
	Total	150	100.0
Highest Educational Qualification	NCE	36	24.0
	B.Ed / B.Sc (Ed) / B.A (Ed)	78	52.0
	B.Sc / B.A + PGDE	21	14.0
	M.Ed / M.Sc (Ed)	12	8.0
	PhD / Others	3	2.0
	Total	150	100.0
Years of Teaching Experience	1–5 years	33	22.0
	6–10 years	51	34.0
	11–15 years	39	26.0
	16–20 years	18	12.0
	Above 20 years	9	6.0
	Total	150	100.0
Type of School	Public Secondary School	150	100.0
	Private Secondary School	0	0.0
	Total	150	100.0

Variable	Category	Frequency	Percentage (%)
Level of Teaching	Junior Secondary only	27	18.0
	Senior Secondary only	66	44.0
	Both Junior and Senior Secondary	57	38.0
	Total	150	100.0
Training on Agro-Digital Technologies (last 5 years)	Yes	42	28.0
	No	108	72.0
	Total	150	100.0
Frequency of Personal Digital Device Use (Professional)	Daily	54	36.0
	Several times a week	48	32.0
	Once a week	27	18.0
	Rarely	18	12.0
	Never	3	2.0
	Total	150	100.0

Note. Source: Field Survey, 2026

Table 1 shows that male teachers constituted 62.0% of respondents. The most represented age group was 30–39 years (38.0%). Most held B.Ed/B.Sc (Ed) degrees (52.0%). A total of 72.0% had received no training on agro-digital technologies in the preceding five years, while 68.0% reported using personal digital devices daily or several times weekly for professional purposes.

Research Question 1

What is the level of knowledge of agro-digital technologies among secondary school agricultural science teachers?

Table 2: Level of Knowledge of Agro-Digital Technologies Among Secondary School Teachers (N = 150)

Agro-Digital Technology	VHK(4)	HK(3)	LK(2)	NK(1)	Mean	SD	Remark
Mobile apps for farm advisory/extension services	24	42	54	30	2.40	1.01	Low
Mobile apps for market prices/buyer connections	30	45	51	24	2.54	1.02	Moderate
Drones (UAVs) for crop monitoring/pest detection	12	27	60	51	2.00	0.94	Low
GIS and GPS for farm mapping	9	24	57	60	1.88	0.91	Low
IoT sensors for soil/weather/livestock	9	21	54	66	1.82	0.91	Low

Agro-Digital Technology	VHK(4)	HK(3)	LK(2)	NK(1)	Mean	SD	Remark
monitoring							
AI tools for yield prediction/disease diagnosis	12	24	57	57	1.94	0.96	Low
Precision farming software/variable-rate tools	6	18	54	72	1.72	0.87	Low
Blockchain applications for traceability	6	15	51	78	1.66	0.84	Low
E-learning platforms/virtual farm simulations	18	33	57	42	2.18	1.00	Low
Digital financial tools/mobile money platforms	36	51	42	21	2.68	1.01	Moderate
Online videos or tutorials on agro-digital tools	54	57	30	9	3.04	0.92	Moderate
Social media for digital marketing	48	54	36	12	2.92	0.97	Moderate
Data analytics tools (spreadsheets) for yield analysis	33	42	48	27	2.54	1.04	Moderate
Remote sensing apps/satellite imagery	9	21	54	66	1.82	0.91	Low
AI chatbots/virtual assistants	9	18	51	72	1.76	0.91	Low
Online marketplaces in enterprise lessons	27	39	51	33	2.40	1.04	Low
Weather forecasting apps for climate risk management	42	48	39	21	2.74	1.03	Moderate
IoT-based smart farming for sustainability topics	9	18	51	72	1.76	0.91	Low
GIS software for farm site selection projects	6	15	54	75	1.68	0.85	Low
Drone footage for pest management illustrations	15	30	57	48	2.08	0.98	Low
Cloud-based platforms for collaborative planning	12	24	54	60	1.92	0.95	Low
Augmented Reality (AR) apps for crop inspection	6	12	45	87	1.58	0.83	Low
Big data tools for agricultural trend analysis	6	12	42	90	1.56	0.83	Low
Mobile payment systems for simulating transactions	30	42	45	33	2.46	1.06	Low
Online certification courses on agro-digital skills	21	33	51	45	2.20	1.03	Low
Grand Mean					2.13	0.94	Low

Note. Source: Field Survey, 2026

The overall level of knowledge remains low, with a grand mean of 2.13. Only six items reached the moderate knowledge threshold, while advanced agriculture-specific tools such as big data tools ($M = 1.56$), augmented reality ($M = 1.58$), and blockchain ($M = 1.66$) recorded the lowest scores.

Research Question 2

What is the extent of utilisation of agro-digital technologies in teaching among teachers?

Table 3: Extent of Utilisation of Agro-Digital Technologies in Teaching (N = 150)

Agro-Digital Technology	Always(4)	Often(3)	Rarely(2)	Never(1)	Mean	SD	Remark
Mobile apps for farm advisory/extension services	15	30	57	48	2.08	0.97	Low
Mobile apps for market prices/buyer connections	18	33	54	45	2.16	1.00	Low
Drones for demonstrating crop monitoring	3	12	42	93	1.50	0.76	Low
GIS/GPS for farm mapping activities	3	9	39	99	1.44	0.72	Low
IoT sensors for soil/weather monitoring	3	9	36	102	1.42	0.72	Low
AI tools for yield prediction/disease lessons	3	12	42	93	1.50	0.76	Low
Precision farming software simulations	3	6	33	108	1.36	0.67	Low
Blockchain examples for traceability	3	6	30	111	1.34	0.66	Low
E-learning platforms/virtual farm simulations	9	21	51	69	1.80	0.91	Low
Digital financial tools for agribusiness finance	21	36	51	42	2.24	1.03	Low
Online videos or tutorials for	42	51	39	18	2.78	1.01	Moderate

Agro-Digital Technology	Always(4)	Often(3)	Rarely(2)	Never(1)	Mean	SD	Remark
demonstrations							
Social media for digital marketing teaching	30	42	48	30	2.48	1.05	Low
Data analytics tools for yield analysis	15	27	54	54	2.02	1.00	Low
Remote sensing apps for land use planning	3	9	36	102	1.44	0.72	Low
AI chatbots for student queries	3	9	33	105	1.40	0.70	Low
Online marketplaces in enterprise lessons	12	24	54	60	1.92	0.96	Low
Weather forecasting apps for climate risk teaching	27	39	48	36	2.38	1.05	Low
IoT-based smart farming for sustainability	3	9	33	105	1.40	0.70	Low
GIS software for farm site selection projects	3	6	30	111	1.34	0.66	Low
Drone footage for pest management illustrations	6	18	48	78	1.68	0.86	Low
Grand Mean					1.84	0.84	Low

Note. Source: Field Survey, 2026

Utilisation is very low across all 20 items (grand mean = 1.84). Only online videos/tutorials reached moderate use (M = 2.78); GIS software (M = 1.34) and blockchain examples (M = 1.34) were the least utilised.

Research Question 3

To what extent do teachers perceive that students' agripreneurship competencies are developed through agro-digital technology use?

Table 4: Perceived Agripreneurship Competencies Developed (N = 150)

Agripreneurship Competency	VHE(4)	HE(3)	LE(2)	NA(1)	Mean	SD	Remark
Innovation and creativity in developing new products/processes	18	33	60	39	2.20	1.00	Low
Business planning and financial	24	39	54	33	2.36	1.04	Low

Agripreneurship Competency	VHE(4)	HE(3)	LE(2)	NA(1)	Mean	SD	Remark
management skills							
Risk assessment and management in agribusiness	21	36	54	39	2.26	1.03	Low
Digital marketing and e-commerce skills	27	39	51	33	2.40	1.06	Low
Value chain integration (handling, processing, packaging)	18	33	57	42	2.18	1.01	Low
Sustainable and climate-smart farming practices	24	36	51	39	2.30	1.06	Low
Leadership, networking, and partnership-building	15	30	60	45	2.10	0.99	Low
Access to and use of digital financial services	21	36	51	42	2.24	1.05	Low
Market research and analysis using digital tools	18	33	54	45	2.16	1.02	Low
Problem-solving in agricultural enterprises using data	18	30	57	45	2.14	1.01	Low
Supply chain management and traceability skills	12	24	54	60	1.92	0.96	Low
Resource efficiency and waste reduction techniques	21	33	54	42	2.22	1.04	Low
Entrepreneurial mindset and self-reliance	27	42	48	33	2.42	1.06	Low
Collaboration and teamwork in agribusiness projects	24	39	51	36	2.34	1.05	Low
Adaptation to technological changes in agriculture	18	33	54	45	2.16	1.02	Low
Ethical practices in digital agribusiness	15	27	54	54	2.02	1.00	Low
Data interpretation for decision-making in farming	15	30	54	51	2.06	1.01	Low
Branding and customer engagement	21	33	51	45	2.20	1.05	Low
Climate resilience planning using predictive tools	15	27	51	57	2.00	1.01	Low
Value addition through digital processing simulations	12	24	51	63	1.90	0.96	Low
Grand Mean					2.16	1.02	Low

Note. Source: Field Survey, 2026

No competency reached the moderate threshold. Entrepreneurial mindset ($M = 2.42$) and digital marketing ($M = 2.40$) scored highest; value addition through digital processing ($M = 1.90$) scored lowest.

Research Question 4

What are the barriers to teachers' adoption of agro-digital technologies?

Table 5: Barriers to Adoption of Agro-Digital Technologies ($N = 150$)

Barrier	SA(4)	A(3)	D(2)	SD(1)	Mean	SD	Remark
Unreliable electricity supply in school	93	42	12	3	3.50	0.74	Strongly Agreed
Poor or no internet connectivity in school	90	45	12	3	3.48	0.75	Agreed
Lack of functional ICT devices	87	42	15	6	3.40	0.84	Agreed
High cost of data bundles/internet subscription	84	45	15	6	3.38	0.83	Agreed
Inadequate personal knowledge/training	81	48	15	6	3.36	0.83	Agreed
Lack of relevant in-service training/workshops	87	45	12	6	3.42	0.80	Agreed
Technologies are too complex or difficult to learn	54	51	33	12	2.98	0.97	Agreed
Tools not relevant to current curriculum	42	48	42	18	2.76	1.01	Agreed
Lack of time to learn and prepare digital lessons	66	54	21	9	3.18	0.91	Agreed
No technical support/maintenance in school	78	48	18	6	3.32	0.84	Agreed
Low student access to smartphones/internet at home	72	45	24	9	3.20	0.93	Agreed
School management does not encourage integration	57	48	33	12	3.00	0.99	Agreed
Cultural resistance from colleagues/students	42	51	42	15	2.80	0.99	Agreed
High cost of acquiring agro-digital tools/software	75	48	21	6	3.28	0.87	Agreed
Lack of policy guidelines on digital integration	66	51	24	9	3.16	0.92	Agreed
Security concerns with digital data	39	48	45	18	2.72	1.00	Agreed
Limited local-language agro-digital content	60	51	27	12	3.06	0.97	Agreed
Overloaded teaching schedule	69	48	24	9	3.18	0.93	Agreed
Poor integration of agro-digital	78	45	18	9	3.28	0.90	Agreed

Barrier	SA(4)	A(3)	D(2)	SD(1)	Mean	SD	Remark
topics in teacher training							
Geographical isolation limiting access to training	72	48	21	9	3.22	0.92	Agreed
Grand Mean					3.17	0.89	Agreed

Note. Source: Field Survey, 2026

All 20 barrier items were agreed with (grand mean = 3.17). Unreliable electricity (M = 3.50), poor internet connectivity (M = 3.48), and inadequate in-service training (M = 3.42) were the most severe barriers.

Research Question 5

What are the strategies for improving teachers' knowledge and use of agro-digital technologies?

Table6: Strategies for Improving Teachers' Knowledge and Use of Agro-Digital Technologies (N = 150)

Strategy	SA(4)	A(3)	D(2)	SD(1)	Mean	SD	Remark
Regular in-service training/workshops	114	30	6	0	3.72	0.53	Strongly Agreed
Provision of functional ICT infrastructure	111	33	6	0	3.70	0.55	Strongly Agreed
Supply of solar power systems	108	33	6	3	3.64	0.64	Strongly Agreed
Curriculum revision to include agro-digital technologies	99	39	9	3	3.56	0.70	Strongly Agreed
Public-private partnerships for subsidized tools/data	102	36	9	3	3.58	0.68	Strongly Agreed
School-based digital agriculture resource centres/labs	105	36	6	3	3.62	0.64	Strongly Agreed
Incentives for teachers who integrate digital tools	87	42	15	6	3.40	0.82	Agreed
Mentoring and peer-learning programmes	84	48	15	3	3.42	0.77	Agreed
Government subsidies for device purchase/data costs	93	42	12	3	3.50	0.73	Strongly Agreed
Agro-digital modules in initial teacher education	99	39	9	3	3.56	0.69	Strongly Agreed
Collaboration with agricultural extension services	90	45	12	3	3.48	0.74	Agreed
Local language agro-digital content and apps	78	51	15	6	3.34	0.83	Agreed
Regular monitoring and evaluation of integration	75	54	18	3	3.34	0.80	Agreed

Strategy	SA(4)	A(3)	D(2)	SD(1)	Mean	SD	Remark
Community involvement to support ICT infrastructure	66	57	21	6	3.22	0.87	Agreed
Online self-paced courses for teachers	81	48	15	6	3.36	0.83	Agreed
Awards for best agro-digital integrated lesson plans	69	51	24	6	3.22	0.89	Agreed
Partnerships with universities for mentorship	84	45	15	6	3.38	0.83	Agreed
Free Wi-Fi hotspots in rural schools	108	33	6	3	3.64	0.63	Strongly Agreed
Agro-digital proficiency in performance appraisals	66	54	24	6	3.20	0.87	Agreed
Funding for field trips to demonstration farms	81	48	15	6	3.36	0.83	Agreed
Grand Mean					3.45	0.74	Agreed

Note. Source: Field Survey, 2026

All 20 strategies were endorsed (grand mean = 3.45), led by regular in-service training (M = 3.72), ICT infrastructure provision (M = 3.70), and free rural Wi-Fi/solar power supply (M = 3.64 each).

Test of Hypotheses

Hypothesis One: No significant difference in agro-digital technology knowledge between male and female teachers.

Table 7: Independent-Samples *t* Test of Gender Differences in Knowledge (N = 150)

Group	N	Mean	SD	t-value	Df	p-value	Decision
Male	93	2.09	0.42				
Female	57	2.19	0.46	-1.34	148	0.182	Fail to Reject Ho

Note. Significance level = 0.05. Source: Field Survey, 2026

There is no statistically significant difference in agro-digital technology knowledge between male and female teachers ($t = -1.34$, $df = 148$, $p = 0.182 > 0.05$).

Hypothesis Two: No significant relationship between years of teaching experience and technology utilisation.

Table 8: Pearson Correlation Between Teaching Experience and Utilisation (N = 150)

Variable	Mean	SD	r-value	p-value	Decision
Years of Teaching Experience	2.46	1.09			
Agro-Digital Technology Utilization	1.84	0.84	0.09	0.273	Fail to Reject Ho

Note. Significance level = 0.05. Source: Field Survey, 2026

The correlation is weak and non-significant ($r = 0.09$, $p = 0.273 > 0.05$), indicating no meaningful relationship between experience and utilisation.

Hypothesis Three: No significant influence of educational qualification on agripreneurship competency development.

Table 9: Descriptive Statistics for Perceived Competency Development by Educational Qualification (N = 150)

Qualification Group	N	Mean	SD
NCE	36	2.04	0.44
B.Ed / B.Sc (Ed) / B.A (Ed)	78	2.18	0.47
B.Sc / B.A + PGDE	21	2.21	0.50
M.Ed / M.Sc (Ed) or above	15	2.36	0.56

Table 10: One-Way ANOVA of the Influence of Educational Qualification on Perceived Competency Development (N = 150)

Source	Sum of Squares	df	Mean Square	F-value	p-value	Decision
Between Groups	2.11	3	0.703	1.42	0.239	Fail to Reject H_0
Within Groups	24.06	146	0.165			
Total	26.17	149				

Note. Significance level = 0.05. Source: Field Survey, 2026

Although teachers with higher qualifications recorded marginally higher competency-development scores, the ANOVA result, $F(3, 146) = 1.42$, $p = 0.239$, is not statistically significant. The null hypothesis is retained.

Discussions

Knowledge of Agro-Digital Technologies

The finding that agricultural science teachers in Odogbolu LGA possess a low overall level of knowledge of agro-digital technologies (grand mean = 2.13) is consistent with a broader pattern in Nigerian secondary education: teachers generally demonstrate stronger self-efficacy in individual technology, pedagogy or content components than in the integrated technological pedagogical content knowledge needed to teach with digital tools. A large-scale survey of 711 Universal Basic Education teachers across Lagos, Oyo, and Ogun States found above-average self-efficacy in the separate TPACK components but a below-average overall TPACK self-efficacy score ($M = 2.48$), indicating that fragmented digital competencies – not an absence of digital exposure – are what constrain effective integration (Olawale et al., 2026). The relatively stronger knowledge of social media platforms and weather forecasting apps observed in the present study aligns with Ogboru's (2025) finding that digital tools with direct consumer utility and smartphone accessibility tend to be more familiar to educators than specialised agro-digital

platforms – a divide that mirrors the broader rural-urban digital gap documented by Olanrewaju et al. (2021).

The deficit in blockchain, augmented reality, big data, IoT, and precision farming software is particularly concerning given that these technologies sit at the centre of Nigeria's agricultural development agenda under the Nigeria Digital Agriculture Strategy 2020–2030 (NITDA, 2020). Mishra and Koehler's (2006) TPACK framework offers a direct explanation: teachers cannot integrate technologies they do not understand, which makes the knowledge gaps identified here a foundational barrier to agripreneurship competency development rather than an incidental one. Olawale et al.'s (2026) finding of fragmented TPACK among Southwest Nigerian teachers more broadly supports this reading, since it shows the same integration failure occurring even where basic technological exposure exists.

Utilisation and the Knowledge-Practice Gap

Utilisation was markedly lower than knowledge (grand mean = 1.84 vs. 2.13), with only online video tutorials reaching a moderate level. This gap is the more instructive finding of the two: it shows that awareness alone does not translate into classroom practice. The Technology Acceptance Model explains this directly: even where some knowledge exists, low perceived ease of use and weak facilitating conditions suppress actual adoption (Davis, 1989). Teachers who reported moderate familiarity with weather apps and social media still rarely used them in instruction, suggesting that curricular irrelevance, time pressure, and the absence of institutional encouragement are doing more to suppress utilisation than lack of awareness is. Choruma et al. (2024) describe the same pattern among smallholder-focused digital agriculture programmes in sub-Saharan Africa: access and awareness are necessary but not sufficient without a supportive ecosystem around them.

Perceived Agripreneurship Competency Development

The uniformly low perceived development of agripreneurship competencies (grand mean = 2.16) follows from the knowledge and utilisation gaps documented above, though this should be read as an association rather than a demonstrated causal chain, given the cross-sectional design and the reliance on teachers' perceptions rather than measured student outcomes. Competencies most dependent on specialised tools – supply chain traceability, value addition through digital processing and predictive climate planning – scored lowest, while entrepreneurial mindset ($M = 2.42$) and digital marketing ($M = 2.40$) scored comparatively higher, likely reflecting the modest reach of social media familiarity among some teachers. This is consistent with Nwibo et al., (2016) argument that agripreneurship development requires genuine technological fluency, not entrepreneurial orientation alone. It also stands in contrast to Adeyanju et al.'s (2023) finding, across Kenya, Nigeria, and Uganda, that youth in structured agripreneurship programmes with mobile-based training and digital market linkages showed significantly stronger innovation and

risk-management outcomes – underscoring what schools in Odogbolu LGA are currently failing to realise, rather than what is unattainable in principle. Direct evidence of the payoff from well-designed digital extension in Nigeria specifically comes from Arouna et al. (2021), whose randomised trial found that personalised digital advisory delivery raised rice yields by roughly 7% and profits by roughly 10% among Nigerian farming households – a scale of benefit that remains inaccessible to Odogbolu LGA students under current levels of teacher utilisation.

Barriers and Strategies

The barriers identified were pervasive rather than isolated: all 20 items were agreed upon (grand mean = 3.17), led by unreliable electricity ($M = 3.50$), poor internet connectivity ($M = 3.48$), and absence of in-service training ($M = 3.42$). This matches evidence that infrastructure deficits and skill gaps are the primary impediments to digital literacy in Nigerian secondary education (Olanrewaju et al., 2021) and that rural infrastructure constraints in sub-Saharan Africa create a baseline deprivation that prevents other enabling factors – training, curriculum reform and incentives – from taking effect at all (Choruma et al., 2024). The near-unanimous endorsement of all 20 proposed strategies (grand mean = 3.45), led by in-service training, ICT infrastructure, solar power, and free rural Wi-Fi, indicates that teachers see this as a systemic problem requiring systemic solutions rather than isolated fixes. Ogun State’s own AgriConnect and AKILIMO initiatives, which combine public-private collaboration with locally adapted advisory content, offer a template already proven at the farmer level that could plausibly be adapted for secondary schools (FMCIDE, 2025; CGIAR, 2025). This is consistent with the federal government’s own July 2025 commitment to a youth-focused 10-year agricultural strategic action plan built around training, mentorship, and monitoring in agro-technology (Nairametrics, 2025), suggesting that teachers’ strategy preferences in this study align with the direction of national policy rather than running ahead of it. The strong endorsement of curriculum reform to integrate agro-digital technologies (mean = 3.56) supports recent calls for systematic agripreneurship curriculum development in Nigerian higher and secondary institutions that explicitly embeds digital competencies rather than treating them as an add-on (Bamiro et al., 2024).

Test of Hypotheses

None of the three hypothesised demographic effects were supported: knowledge did not differ significantly by gender ($t = -1.34$, $p = 0.182$), utilisation was not significantly correlated with years of teaching experience ($r = 0.09$, $p = 0.273$), and qualification level did not significantly predict perceived competency development ($F = 1.42$, $p = 0.239$). Read alongside the barrier data, this pattern is coherent rather than incidental: the top-rated barriers were structural (electricity, connectivity, device availability, absence of training) rather than individual, and structural constraints apply uniformly across a school regardless of a given teacher’s sex, years of service, or degree. A teacher with fifteen years’ experience and an M.Ed. is not meaningfully

better positioned to use IoT sensors or drones in a classroom with no electricity than a first-year NCE graduate in the same building. Olawale et al.'s (2026) large-sample UBE study offers a partial parallel: they similarly found no significant gender difference in TPACK self-efficacy, even while experience and institutional support did produce significant differences in their sample – suggesting that gender specifically, rather than demographic variables in general, may be the more consistently non-explanatory factor across Nigerian contexts, while experience and support effects may depend on how uniformly infrastructure is distributed within a given study area. In Odogbolu LGA's case, the near-total absence of infrastructure across schools plausibly flattens any experience or qualification effect that might otherwise emerge.

Conclusion

Agricultural science teachers in Odogbolu LGA exhibit low knowledge and markedly lower utilisation of agro-digital technologies, resulting in minimal development of agripreneurship competencies among students. These deficits are driven primarily by infrastructural deprivation and inadequate professional development rather than individual teacher characteristics. Given the study's cross-sectional design and reliance on self-reported data, findings should be interpreted with appropriate caution.

Recommendations

Based on the findings, the following are recommended:

- i. Curriculum revision to embed agro-digital content in secondary school agricultural science instruction.
- ii. Investment in rural school electricity and internet connectivity to address the most severe infrastructural barriers identified.
- iii. Establishment of school-based digital agriculture resource centres/labs.
- iv. Sustained, TPACK-grounded in-service training and mentoring for teachers.
- v. Expansion of public-private partnerships, building on existing models such as AgriConnect and AKILIMO, to extend digital agriculture infrastructure into secondary education.
- vi. Further longitudinal, multi-LGA, and mixed-methods research to build a more generalisable evidence base.

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School Inspectors' Supervisory Behaviour and Teachers' Instructional Practices in Public Primary Schools in Osogbo Local Government Area, Osun State, Nigeria

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Abstract

This study examined primary school teachers' perceptions of school inspectors' supervisory behaviour and the perceived effects of such behaviour on teachers' instructional practices and pupils' learning outcomes in Osogbo Local Government Area, Osun State, Nigeria. The study adopted a descriptive survey research design. A sample of 200 teachers was selected from 20 public primary schools in the study area, with 10 teachers selected from each sampled school. Data were collected using a structured questionnaire titled School Inspectors' Supervisory Behaviour and Teachers' Instructional Practices Questionnaire (SISBTIPQ). The instrument was subjected to face and content validation by two experts, while its internal consistency was established using Cronbach's alpha, which yielded a coefficient of 0.78. Data were analysed using frequency counts, percentages, mean and standard deviation, with a criterion mean of 2.50. The findings revealed that teachers had an unfavourable perception of school inspectors' supervisory behaviour, as indicated by a grand mean of 1.87. Similarly, teachers did not perceive inspectors' supervisory behaviour as making a substantial positive contribution to their instructional practices and pupils' learning outcomes, with a grand mean of 1.86. The factors examined in relation to teachers' perceptions also recorded a grand mean of 1.99, indicating that none was strongly endorsed based on the criterion mean. The study concludes that school inspection in the study area needs to place greater emphasis on constructive feedback, professional communication, collaboration, teacher development and follow-up support. It is recommended that school inspectors adopt more supportive and developmental approaches to supervision to enhance teachers' instructional practices and the quality of primary education.

Keywords: School Inspectors, Supervisory Behaviour, Teachers' Instructional Practices

Introduction

School supervision is an important component of educational administration and management because it provides a mechanism for monitoring instructional activities, supporting teachers and ensuring that educational standards are maintained. In primary education, effective supervision is particularly important because the quality of teachers' instructional practices contributes to pupils' acquisition of foundational knowledge, skills and attitudes. School inspectors are therefore expected to monitor teaching and learning activities, provide professional guidance, identify areas requiring improvement and promote compliance with established educational standards. Traditionally, school inspection has been associated with monitoring, evaluation and accountability. Contemporary approaches to educational supervision, however, increasingly emphasise professional support, constructive feedback, collaboration and teacher development. Effective supervisory behaviour should therefore extend beyond the identification of weaknesses to include practical guidance that enables teachers to understand their strengths and areas requiring improvement. Teachers' perceptions of supervision are important because the manner in which supervisory activities are conducted may influence teachers' willingness to accept feedback and implement recommendations. Supervisory practices perceived as punitive, fault-finding or unfair may generate resistance, whereas supportive and constructive supervision may encourage professional development and improvement in teaching practices. Previous studies have highlighted the importance of instructional supervision in maintaining educational standards and improving teaching effectiveness.

Previous studies have examined supervisory practices, the maintenance of educational standards through effective supervision, and the relationship between supervision and instructional outcomes; these are reviewed in detail in the Literature Review. Despite the recognised importance of school inspection, there is a need to examine how teachers in specific educational contexts perceive inspectors' supervisory behaviour. Teachers' perceptions provide useful information about whether supervisory practices are experienced as supportive, developmental and professionally beneficial. The present study therefore examined primary school teachers' perceptions of school inspectors' supervisory behaviour in Osogbo Local Government Area, Osun State, Nigeria.

Statement of the Problem

School inspection is intended to contribute to the improvement of teaching and learning by monitoring instructional practices, identifying areas of weakness and providing professional guidance. However, the effectiveness of inspection may depend substantially on how supervisory activities are conducted and perceived by teachers. Where teachers perceive inspectors as primarily concerned with fault-finding, criticism and judgement, inspection may be viewed as punitive rather than developmental. Such perceptions may limit teachers' willingness to accept

supervisory recommendations and may reduce the potential contribution of inspection to instructional improvement. The concern addressed by this study is therefore not simply whether school inspectors visit schools, but how teachers perceive their supervisory behaviour and whether they perceive such behaviour as contributing to improvements in teaching and learning. The study consequently investigated teachers' perceptions of supervisory behaviour, the perceived effects of supervision on instructional practices and pupils' learning outcomes, and factors that teachers considered in forming their perceptions.

Purpose of the Study

The purpose of the study was to examine primary school teachers' perceptions of school inspectors' supervisory behaviour in public primary schools in Osogbo Local Government Area, Osun State. Specifically, the study sought to:

1. examine teachers' perceptions of school inspectors' supervisory behaviour;
2. determine teachers' perceived effects of inspectors' supervisory behaviour on instructional practices and pupils' learning outcomes and
3. examine factors perceived by teachers as influencing their perceptions of school inspectors' supervisory behaviour.

Research Questions

The study was guided by the following research questions:

1. What is the perception of primary school teachers in Osogbo Local Government Area regarding the supervisory behaviour of school inspectors?
2. What are the perceived effects of school inspectors' supervisory behaviour on teachers' instructional practices and pupils' learning outcomes?
3. What factors do primary school teachers perceive as influencing their perceptions of school inspectors' supervisory behaviour?

Literature Review

School inspection involves the systematic examination and monitoring of educational activities to determine the extent to which schools and teachers are meeting established educational expectations and standards. Supervision, on the other hand, encompasses professional activities intended to guide, support and improve teaching and learning. Effective inspection should therefore combine accountability with professional support. Rather than focusing exclusively on identifying deficiencies, inspectors can contribute more effectively to school improvement by providing constructive feedback, facilitating professional dialogue and supporting teachers in addressing identified instructional challenges.

Supervisory behaviour refers to the manner in which supervisors interact with teachers and carry out supervisory responsibilities. Important dimensions include communication,

fairness, approachability, professional competence, feedback, interpersonal relationships and follow-up support. Teachers' perception of these behaviours is important because the same supervisory activity may be interpreted differently depending on the approach adopted by the inspector. Supportive communication and constructive feedback may encourage teachers to reflect on their practices, whereas authoritarian or fault-finding approaches may generate anxiety and resistance.

Instructional supervision is intended to improve teaching by helping teachers identify strengths and areas requiring development. Areas that may benefit from effective supervision include lesson planning, lesson delivery, assessment of learning, classroom management, use of innovative teaching methods and responsiveness to diverse learner needs. Where supervisory recommendations are accompanied by meaningful feedback and follow-up support, teachers may be better positioned to implement improvements in classroom practice.

Ajayi (2018) reported concerns regarding supervisory practices that emphasised criticism and identification of teachers' deficiencies. Such an approach may weaken the developmental purpose of supervision. Ijaiya (2022) highlighted the contribution of effective supervision to the maintenance of educational standards. The implication is that the quality of supervisory practice is important to the extent to which inspection contributes to school improvement. Glanz (2021) reported an association between classroom visitations and students' academic performance, suggesting that classroom supervision can potentially contribute to improved educational outcomes. Ogunode and Ibrahim (2023) emphasised aspects such as planning and preparation, lesson presentation and teachers' professional characteristics in instructional supervision. The reviewed literature suggests that effective supervision has the potential to contribute to educational quality. However, the present study focuses specifically on teachers' perceptions of school inspectors' supervisory behaviour in public primary schools in Osogbo Local Government Area.

Methodology

The study adopted a descriptive survey research design. The design was considered appropriate because the study sought to obtain information directly from primary school teachers concerning their perceptions of school inspectors' supervisory behaviour and the perceived effects of supervision on instructional practices and pupils' learning outcomes. A sample of 200 teachers participated in the study. The teachers were randomly sampled from 20 selected public primary schools in the Local Government. Using simple random sampling technique to select 10 teachers from each of the selected schools. Data were collected using a structured questionnaire titled School Inspectors' Supervisory Behaviour and Teachers' Instructional Practices Questionnaire (SISBTIPQ). The questionnaire contained sections addressing respondents' relevant demographic characteristics, teachers' perceptions of school inspectors' supervisory behaviour,

perceived effects of supervision on instructional practices and pupils' learning outcomes and factors associated with teachers' perceptions. Items were measured on a four-point Likert scale as Strongly Disagree = 1, Disagree = 2, Agree = 3, Strongly Agree = 4. The instrument was subjected to face and content validation by two experts in Educational Management and related fields. Their observations were used to establish the adequacy and relevance of the questionnaire items. A pilot administration was conducted using respondents who were not included in the main study. The internal consistency of the instrument was determined using Cronbach's alpha. A reliability coefficient of 0.78 was obtained, indicating an acceptable level of internal consistency for the instrument. The questionnaire was administered to the sampled teachers in the selected public primary schools. Respondents were informed about the purpose of the study and were encouraged to provide honest responses. Data were analysed using frequency counts, percentages, mean and standard deviation. A criterion means of 2.50 was adopted for interpreting the four-point Likert scale. Mean scores from 2.50 to 4.00 were interpreted as agreement, while mean scores from 1.00 to 2.49 were interpreted as disagreement. Negatively worded items were reverse-coded where composite interpretation required scores to be aligned in the same direction. Because the study employed a descriptive survey design, findings concerning instructional practices and pupils' learning outcomes were interpreted as perceived effects and not as evidence of causal effects. Participation in the study was voluntary. Respondents were informed about the purpose of the research and assured that information provided would be treated confidentially and used strictly for research purposes. Anonymity and confidentiality were maintained throughout the study.

Results

Research Question 1

What is the perception of primary school teachers in Osogbo Local Government Area regarding the supervisory behaviour of school inspectors?

Table 1. Teachers' perception of school inspectors' supervisory behaviour (N = 200)

Table 1. Teachers' perception of school inspectors' supervisory behaviour (N = 200)

S/N	ITEMS	RESPONSE								Mea n	SD
		Strongly Disagree		Disagree		Agree		Strongly Agree			
		f	%	F	%	F	%	F	%		
1	Inspectors provide constructive feedback that helps improve teaching skills	99	49.5%	94	47.0%	4	2.0%	3	1.5%	1.55	0.62

2	Supervisory behaviour is fair and unbiased	79 39.5%	90 45.0%	28 14.0%	3 1.5%	1.77	0.7 4
3	Inspectors are approachable and open to teachers' suggestions	79 39.5%	86 43.0%	22 11.0%	13 6.5%	1.84	0.8 6
4	Frequency of inspectors' visits is adequate.	37 18.5%	125 62.5%	29 14.5%	9 4.5%	2.05	0.7 1
5	Inspectors focus more on fault-finding than supporting teachers	57 28.5%	58 29.0%	66 33.0%	19 9.5%	2.23	0.9 7
6	Supervisory behaviour has improved teachers' job satisfaction	89 44.5%	88 44.0%	18 9.0%	5 2.5%	1.70	0.7 4
7	Inspectors are knowledgeable about the subjects they supervise	65 32.5%	98 49.0%	22 11.0%	15 7.5%	1.94	0.8 6
Grand Mean						1.87	

Table 1 indicates that the mean scores ranged from 1.55 to 2.23, with a grand mean of 1.87. Since the grand mean is below the criterion mean of 2.50, the findings indicate that teachers generally had an unfavourable perception of school inspectors' supervisory behaviour.

The lowest mean score was recorded for constructive feedback ($M = 1.55$, $SD = 0.62$), suggesting that respondents generally did not agree that inspectors provided constructive feedback that helped improve their teaching skills. Fairness and unbiased supervision also recorded a relatively low mean ($M = 1.77$, $SD = 0.74$), as did approachability and openness to teachers' suggestions ($M = 1.84$, $SD = 0.86$). The findings therefore suggest that teachers did not generally perceive the supervisory behaviour of school inspectors as sufficiently supportive, constructive or developmental.

Research Question 2

What are the perceived effects of school inspectors' supervisory behaviour on teachers' instructional practices and pupils' learning outcomes?

Table 2. Perceived effect of supervisory behaviour on instructional practices and learning outcomes (N = 200)

		RESPONSE									
S/ N	ITEMS	Strongly Disagree		Disagree		Agree		Strongly Agree		Mean	SD
		F	%	f	%	f	%	F	%		
1	Supervision has helped improve lesson planning and delivery.	79		106		12		3		1.70	0.65
			39.5%		53.0%		6.0%		1.5%		
2	Inspectors' feedback has enabled identification of areas for improvement	91		90		14		5		1.67	0.72
			45.5%		45.0%		7.0%		2.5%		
3	Supervision has increased the use of innovative teaching methods.	79		92		12		17		1.83	0.88
			39.5%		46.0%		6.0%		8.5%		
4	Supervision has a positive effect on pupils' academic performance	59		118		16		7		1.85	0.70
			29.5%		59.0%		8.0%		3.5%		
5	Inspection visits have led to increased stress and anxiety.	33		72		58		37		2.50	0.98
			16.5%		36.0%		29.0%		18.5%		
6	Supervision has helped teachers assess and evaluate pupils' learning outcomes	73		100		16		11		1.82	0.80
			36.5%		50.0%		8.0%		5.5%		
7	Supervision has enhanced teachers' ability to meet diverse pupil needs.	87		98		8		7		1.68	0.72
			43.5%		49.0%		4.0%		3.5%		
Grand Mean										1.86	

Table 2 shows that the mean scores ranged from 1.67 to 2.50, with a grand mean of 1.86. The grand mean is below the criterion mean of 2.50, indicating that teachers generally did not perceive school inspectors' supervisory behaviour as making a substantial positive contribution to their instructional practices and pupils' learning outcomes. The lowest mean score was recorded for inspectors' feedback enabling teachers to identify areas for improvement ($M = 1.67$, $SD = 0.72$), followed by teachers' ability to meet diverse pupil needs ($M = 1.68$, $SD = 0.72$). Lesson planning and delivery recorded a mean of 1.70, while assessment and evaluation of pupils' learning outcomes recorded a mean of 1.82. The item relating to increased stress and anxiety recorded a mean of 2.50 ($SD = 0.98$), which exactly met the criterion mean, marking borderline agreement among teachers that inspection visits increased stress and anxiety. Overall, the findings indicate that respondents did not perceive supervision as making a substantial positive contribution to instructional practices and pupils' learning outcomes.

Research Question 3

What factors do primary school teachers perceive as influencing their perceptions of school inspectors' supervisory behaviour?

Table 3. Factors associated with teachers' perceptions of supervisory behaviour (N = 200)

S/N	Factors	Mean	SD
1.	Communication style of inspectors	1.75	0.62
2.	Inspectors' subject-matter expertise	2.00	0.91
3.	Frequency and consistency of inspection visits	1.89	0.81
4.	Feedback and follow-up actions	1.86	0.74
5.	Inspectors' attitude and demeanour	2.21	0.98
6.	Knowledge of school context and challenges	2.17	0.85
7.	Support and resources provided by inspectors	2.08	0.87
	Grand Mean	1.99	

Table 3 indicates that the mean scores ranged from 1.75 to 2.21, with a grand mean of 1.99. Since the grand mean is below the criterion mean of 2.50, the respondents did not strongly endorse the listed factors under the decision criterion.

Inspectors' attitude and demeanour recorded the highest mean ($M = 2.21$, $SD = 0.98$), followed by knowledge of school context and challenges ($M = 2.17$, $SD = 0.85$) and support and resources provided by inspectors ($M = 2.08$, $SD = 0.87$). Communication style recorded the lowest mean ($M = 1.75$, $SD = 0.62$).

Discussion of Findings

The empirical findings presented in Tables 1 to 3 provide evidence on primary school teachers' perceptions of school inspectors' supervisory behaviour, the perceived effects of that behaviour on instructional practices and pupils' learning outcomes, and the factors associated with those perceptions. Data were evaluated against a criterion mean of 2.50 on the four-point scale, with mean scores below 2.50 interpreted as disagreement. The grand mean for supervisory behaviour ($M = 1.87$) in Table 1, for perceived instructional and learning effects ($M = 1.86$) in Table 2, and for associated factors ($M = 1.99$) in Table 3 all fell below this threshold, indicating a broadly unfavourable perception of school inspectors' supervisory behaviour among the teachers sampled.

In Table 1, the lowest-rated item was "Inspectors provide constructive feedback that helps improve teaching skills" ($M = 1.55$, $SD = 0.62$), whereas the highest-rated item, "Inspectors focus more on fault-finding than supporting teachers" ($M = 2.23$, $SD = 0.97$), still fell below the criterion mean, though closer to it than the other items. This pattern suggests that teachers associated inspection visits more closely with the identification of weaknesses than with constructive mentoring. The finding is consistent with Ajayi (2018), who reported concerns regarding supervisory practices dominated by fault-finding, judgement and criticism, and with Quintelier et al. (2020), who found that when teachers perceive inspection feedback as narrowly

compliance-focused, their acceptance of that feedback declines. Al-Hosni (2021) similarly observed that supervisory models oriented toward error identification can lead teachers to regard inspectors as adversaries rather than as pedagogical partners. Related items on fairness ($M = 1.77$, $SD = 0.74$), approachability ($M = 1.84$, $SD = 0.86$) and subject knowledge ($M = 1.94$, $SD = 0.86$) were also rated low, suggesting that respondents questioned inspectors' procedural fairness and subject competence; this aligns with Maldrine and Kiplangat (2020), who argued that effective supervision depends on procedural justice, open dialogue and specialised content knowledge.

Table 2 showed uniformly low mean scores across the instructional indicators, including feedback enabling identification of areas for improvement ($M = 1.67$, $SD = 0.72$), ability to meet diverse pupil needs ($M = 1.68$, $SD = 0.72$) and lesson planning and delivery ($M = 1.70$, $SD = 0.65$), indicating that respondents did not perceive supervision as making a substantial positive contribution to their instructional practice. This is consistent with Penninckx and Vanhoof (2015), who found that external inspection visits rarely produce sustainable pedagogical improvement unless accompanied by sustained internal support, and with Jones and O'Brien (2025), who reported that inspection visits focused on documentation review rather than live instructional coaching do little to help teachers address classroom challenges such as learner diversity. The finding differs from Glanz (2021), who reported an association between classroom visitations and students' academic performance; the difference may reflect differences in context, population and methodology, since the present study relied on teachers' perceptions rather than an objective measure of pupil performance.

Item 5 of Table 2, "Inspection visits have led to increased stress and anxiety", recorded a mean of 2.50 ($SD = 0.98$), exactly meeting the criterion mean. This represents borderline rather than strong agreement: taken together with the low rating for the job-satisfaction item in Table 1 ($M = 1.70$, $SD = 0.74$), it suggests that while teachers did not perceive supervision as improving job satisfaction, the perception that inspection contributes to stress and anxiety was not strongly or uniformly held either. The finding nonetheless resonates with Fitzsimons and Smith (2025), who documented that unpredictable, high-stakes inspection regimes can generate chronic stress among educators, and with Perry et al. (2025), who linked punitive inspection environments to occupational anxiety and reduced job satisfaction.

The factors examined in Table 3 also fell below the criterion mean (grand mean = 1.99), indicating that none was regarded as strongly characterising inspectors' practice. Inspectors' attitude and demeanour recorded the highest mean ($M = 2.21$, $SD = 0.98$), followed by knowledge of school context and challenges ($M = 2.17$, $SD = 0.85$) and support and resources provided by inspectors ($M = 2.08$, $SD = 0.87$), suggesting that interpersonal and contextual sensitivity were comparatively better regarded than other dimensions of supervisory practice. This is consistent with Quintelier et al. (2020), who found that inspectors' interpersonal approach

and contextual empathy shape teachers' willingness to accept inspection outcomes, and with Zarco (2024), who reported that teachers view supervision more positively when supervisors demonstrate awareness of local constraints. By contrast, communication style recorded the lowest mean overall ($M = 1.75$, $SD = 0.62$), and feedback and follow-up actions ($M = 1.86$, $SD = 0.74$) and subject-matter expertise ($M = 2.00$, $SD = 0.91$) were also rated low. Gordon (2019) similarly emphasised that supervisor credibility depends on specialised subject expertise, Mendoza and Hife (2020) linked inconsistent supervision schedules to teacher anxiety rather than professional growth, and Pomentel (2024) identified communication style as a critical factor in building trust between teachers and supervisory authorities. Al-Hosni (2021) further noted that the absence of constructive follow-up after inspection leads teachers to regard inspection as a bureaucratic exercise rather than a developmental one. These findings broadly align with Onasanya (2018), who emphasised the importance of supervision and inspection practices grounded in professional relationship-building within public primary schools.

Overall, the findings suggest that teachers in the study area experienced school inspection as oriented more toward monitoring and fault identification than toward constructive, developmental support. Because the study adopted a descriptive survey design and relied on teachers' self-reported perceptions, the findings should be interpreted as evidence of perceived rather than actual or causal effects of inspection on instructional practice or pupil outcomes. They point, nonetheless, to the value of strengthening inspectors' communication, professional attitude, contextual sensitivity and follow-up support as part of a more developmental approach to school inspection.

Conclusion

The study concludes that primary school teachers in Osogbo Local Government Area generally had an unfavourable perception of school inspectors' supervisory behaviour. Teachers did not perceive inspectors' supervisory activities as making a substantial positive contribution to their instructional practices and pupils' learning outcomes. The study further found that the identified factors were not strongly endorsed under the criterion mean used for interpretation. Nevertheless, the findings point to the importance of inspectors' attitudes, communication, contextual understanding, professional competence, feedback and follow-up support in creating a more constructive supervisory environment. Since the study adopted a descriptive survey design and relied on teachers' perceptions, the findings should not be interpreted as evidence of causal effects of inspection on teachers' instructional practices or pupils' academic achievement.

Implications of the Study

The findings have implications for educational administrators, school inspectors and policymakers. School inspection should not be limited to monitoring and accountability.

Inspectors should also function as professional support providers who help teachers identify instructional challenges and develop practical strategies for addressing them.

Educational authorities should therefore consider strengthening inspectors' competencies in communication, mentoring, instructional feedback and collaborative problem-solving. A more developmental approach may improve teachers' acceptance of supervision and increase the usefulness of inspection activities.

Recommendations

Based on the findings, the study recommends that:

- Constructive feedback should be strengthened. School inspectors should provide specific feedback after inspection visits, identifying teachers' strengths, areas requiring improvement and practical strategies for addressing identified weaknesses.
- Inspection should adopt a more developmental approach. Inspectors should reduce practices that may be perceived as fault-finding and promote professional dialogue, collaboration and problem-solving.
- Follow-up activities should be institutionalised. Recommendations made during inspection should be followed by appropriate professional guidance and subsequent monitoring.
- Inspectors should strengthen communication and interpersonal skills. Respectful and professional interaction with teachers should form an important component of supervisory practice.
- Professional development for inspectors should be enhanced. Educational authorities should provide continuous professional development in instructional supervision, mentoring, communication, feedback and teacher support.

Limitations of the Study

The study was based on teachers' self-reported perceptions and employed a descriptive survey design. Consequently, the findings cannot establish causal relationships between school inspectors' supervisory behaviour and teachers' instructional practices or pupils' academic achievement. In addition, the study focused on public primary schools in Osogbo Local Government Area. Therefore, caution should be exercised when generalising the findings to other local government areas or school types.

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