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CONFERENCE PROCEEDINGS
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CONFERENCE PROCEEDINGS OF THE AITIE 7TH INTERNATIONAL CONFERENCE AND WORKSHOP ON INNOVATION, TECHNOLOGY AND EDUCATION (ICWITE, LAGOS 2025)

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Prof. Sunday Adebisi	Keynote Speaker	Director Entrepreneurship and Skills Development Centre,University of Lagos, Nigeria, Director, African Research Universities Alliance (ARUA) Centre of Excellence for Unemployment and Skills Development
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Dr. Nokulunga Ndlovu	Lead Paper Presenter II	University of Witswatersrand, Johannesburg South Africa
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Workshop Facilitators

Facilitator	Address	Track
Dr. Deji Ajani	University of Johannesburg, South Africa	Track 1: EduTechpreneurship
Faith Olabisi	EduSpark, Lagos, Nigeria	Track 2: Robotics
Adebayo Alomaja **Abisola Jegede**	Easy-Digi, Lagos, Nigeria NITHUB, Lagos, Nigeria	Track 3: Design Thinking

AITIE

Creative minds innovate to transform the world.

They innovate through forward-thinking ideas to create the desired values.

Beyond the politics of educational research for certification lies the politics of educational research for transformation.

Only the network of dedicated and technology literate individuals can constructively integrate technology to support learning.

Through creative thinking, research and praxes we must Domesticate, Innovate and Integrate Technology for Instruction

INTERNATIONAL CONFERENCE AND WORKSHOP ON INNOVATION, TECHNOLOGY AND EDUCATION

This conference is dedicated to educators globally, the legends and pioneers who have made contributions into the integration of media in the Nigerian educational system and to the members of the Association for Innovative Technology Integration in Education (AITIE) who have the desire to facilitate learning in variety of educational settings through innovative and creative use of technology

Vision

To be the foremost professional association in the integration of technologies for teaching, learning, research and administrative purposes in conventional and distance education settings.

Mission

We seek to be a force for qualitative accessible education, through the promotion of scholarship and best practices in the design, development, use, and innovative management of technologies for effective teaching and learning in a variety of educational settings.

Core Values

The following principles guide our work and define the mission of AITIE:

- **access to quality education**: a commitment to access to quality education for all, irrespective of location, gender, race, religion, disability, etc., as education is a human right and an instrument for poverty alleviation and sustainable human development;
- **excellence**: promotion of quality research, teaching, learning, and life-changing scholarship and value-based service, through innovative use of technology
- **innovation and creativity**: encouragement of intellectual inquisitiveness through the promotion of technology for enhanced lifelong learning
- **teamwork**: encouragement of collaboration among individual and institutional members and promotion of shared values in the integration of information and communication technology in all aspects of education;
- **continuing professional education**: promotion of quality professional education for members and graduates already in the workforce;
- **association, institutions and industry collaboration**: encouraging closer social and economic ties among the Association, other professional associations, educational institutions, and the industry;
- **academic and professional integrity**: commitment to maintaining academic quality and standards, and integrity in all programmes of the association.
- **resources for teaching and learning**: commitment to providing resources for teaching, learning, research, and administration in conventional and distance education settings; and
- **Professionalism**: expertise and judgment of educational technology and related media professionals are critical to the successful integration of technology in education. AITIE maintains the highest professional standards and expects status, compensation, and respect due to all professionals.

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PRESIDENTIAL ADDRESS AT THE 2025 AITIE CONFERENCE

A WELCOME ADDRESS DELIVERED BY PROFESSOR AMOSA ISIAKA GAMBARI, NATIONAL PRESIDENT, ASSOCIATION FOR INNOVATIVE TECHNOLOGY INTEGRATION IN EDUCATION (AITIE) ON THE OCCASION OF THE 7TH INTERNATIONAL CONFERENCE AND WORKSHOP ON INNOVATION, TECHNOLOGY AND EDUCATION

Holding from 10th – 15th august, 2025 at the Paul Alabi Hall, Federal College of Education (Technical), Akoka, Lagos State, Nigeria

PROTOCOL

It is with deep gratitude to Almighty Allah that I welcome you all, on behalf of the Association for Innovative Technology Integration in Education (AITIE), to the 7th International Conference and Workshop on Innovation, Technology, and Education. We extend our heartfelt appreciation to the Provost, Management, and entire community of the Federal College of Education (Technical), Akoka, for graciously hosting us at this noble institution. Your support and goodwill continue to sustain and inspire our mission.

Mr. Chairman, distinguished guests, ladies and gentlemen, permit me to proudly welcome our keynote presenter for this year's conference, Prof. Sunday A. Adebisi, a renowned education technologist and the Director of the Entrepreneurship and Skills Development Centre at the University of Lagos, Nigeria, and Director of the African Research Universities Alliance (ARUA) Centre of Excellence for Unemployment and Skills Development. This is the man whose activities have made the University of Lagos the hub leader in Nigeria and Africa for research in youth unemployment and sustainable entrepreneurship. His wealth of experience and insight will certainly inspire our reflections throughout this conference.

We are equally delighted to welcome our lead paper presenters:
1. Prof. Olugbenga Gabriel Akindoju, the Dean, Faculty of Education, Lagos State University, Ojo. A professor of computer education who has worked as a consultant on educational projects and interventions with various organisations such as NERDC, UBEC, WAEC, UNESCO, USAID, DFID, and the World Bank.

2. Dr. Nokulunga Ndlovu, an academic researcher affiliated with the University of the Witwatersrand (Wits), South Africa. She is a specialist in Information and Communication Technology (ICT) in Education, Online Learning, and ICT Policy Implementation.
3. Prof. Keziah Achounye, an erudite professor at the Department of Curriculum Studies and Instructional Technology, Ignatius Ajuru University of Education, Port Harcourt, Rivers State, Nigeria, whose contributions to educational technology in Nigeria have been significant and exemplary.

We also welcome Mr. Adedayo Alomaja, Easy-Digi, Lagos, Nigeria; Dr. Deji Ajani, University of Johannesburg, South Africa; Mrs. Abisola Jegede, NITHUB, Lagos, Nigeria; and Mr. Faith

Olabisi, EduSpark, Lagos, Nigeria, for honouring our invitation and providing a wonderful hands-on training on edupreneurship, robotics, AI, and deep thinking for educational products.

We wish to wholeheartedly welcome all our invited guests, partners, and stakeholders who have honoured our invitation to participate in this landmark conference. To all participants who have journeyed from different institutions across Nigeria and beyond, we deeply appreciate your presence and commitment to advancing innovation in education.

I wish to commend the Local Organizing Committee for their tireless efforts in planning this conference. Your dedication has made this gathering of national and international experts a reality. My special appreciation also goes to our mentor and the visionary founder of AITIE, Prof. Mudasiru Olalere Yusuf, a trailblazer and distinguished scholar who continues to inspire generations.

The theme of this year’s conference, "Edtechpreneurship: Access, Equity, and Innovative Technologies for School Settings and Workplace," is both timely and crucial. It reflects the growing need to explore entrepreneurial approaches that are inclusive, affordable, and scalable to educational technology.

We are at a turning point in educational innovation. From digital equity and inclusive access to skills development and sustainable EdTech models, the sub-themes of this conference provide a roadmap for addressing some of the most pressing educational challenges in our society today. This gathering will allow us to deliberate on issues ranging from ethical considerations in EdTech entrepreneurship to public-private partnerships, profitability, and policy integration.

In a rapidly globalizing and digital world, we cannot afford to lag. We must embrace innovation, not just in policy but in practice. As educators, researchers, innovators, and entrepreneurs, we are tasked with rethinking the future of learning and work.

Let me encourage all participants to engage actively in the plenaries, workshops, and networking sessions. This conference is not only a forum for knowledge sharing but also a fertile ground for collaboration and innovative solutions that can transform our educational and professional landscapes.

Chairman, ladies and gentlemen, I am convinced that this year’s event will be impactful and memorable. Let us continue to build bridges between technology and education in ways that promote equity, innovation, and access for all.

I wish everyone fruitful deliberations, meaningful connections, and a pleasant stay here in Lagos, the Centre of Excellence. Please feel at home, explore the beauty and vibrancy of Lagos, and most importantly, take home knowledge and inspiration that will ignite positive changes in your institutions and communities.

Thank you, and God bless you.

Prof. Amosa Isiaka Gambari
National President, AITIE

PIXELATING PROGRESS: EDTECH ENTREPRENEURSHIP AS A CATALYST FOR INCLUSIVE LEARNING ECOSYSTEMS

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Abstract
This paper explores the evolving landscape of EdTech entrepreneurship as a transformative force in advancing equitable and inclusive education, particularly in developing contexts like Nigeria. While EdTech has shown great promise in expanding access and customizing learning experiences, disparities in connectivity, infrastructure, funding, and socio-cultural adaptation persist. Through deeper analysis and global/Nigerian case illustrations—from Kenya's M-Shule to Nigeria's Tuteria and government-backed Lagos State initiatives—this paper demonstrates the dual potential and pitfalls of digital learning systems. Drawing on policy, pedagogical frameworks, and real-world examples, this work aims to provide critical insights for educators, entrepreneurs, and policymakers reimagining inclusive education ecosystems in the 21st century

Introduction

Education is universally recognized as both a fundamental human right and a pivotal catalyst for socio-economic advancement. Nonetheless, persistent systemic inequities in access, quality, and adaptability continue to undermine its universal potential. In numerous regions of the Global South, including Nigeria, millions of students find themselves either excluded from formal educational opportunities or subjected to under-resourced, antiquated, and inflexible educational frameworks. The COVID-19 pandemic has exacerbated these disparities, illuminated the vulnerability of conventional educational models and emphasized the necessity for alternative, technology-enabled learning avenues.

Within this framework, the emergence of EdTech entrepreneurship has transcended mere trendiness, evolving into a formidable tool for re-envisioning educational delivery. Ranging from mobile learning applications to adaptive educational platforms, EdTech initiatives are addressing infrastructural deficiencies, generating localized content, and significantly empowering learners on a large scale. In Nigeria, platforms such as uLesson, Edukoya, and Tuteria have tailored their content to facilitate both examination readiness and lifelong learning, indicative of a burgeoning ecosystem that harmonizes innovation with meaningful impact. This article investigates the capacity of EdTech entrepreneurship to serve as a catalyst for inclusive learning ecosystems, with a particular focus on the confluence of technology, innovation, and educational equity.

The subsequent sections will thoroughly examine the paradoxes associated with EdTech adoption, obstacles to digital inclusion, strategies for personalized and culturally pertinent learning experiences, as well as the entrepreneurial and policy frameworks that can nurture sustainable inclusive innovation. A comparative analysis will be conducted, juxtaposing global examples with local innovations to provide a nuanced and grounded perspective for educators, policymakers, investors, and innovators.

The Promise and Paradox of EdTech

EdTech is extensively celebrated for its promise to democratize education by surmounting geographical, social, and economic barriers. Through the utilization of virtual classrooms and AI-enhanced learning platforms, technology has facilitated the extension of educational opportunities beyond the physical boundaries of traditional schools, thereby reaching previously underserved demographics. On a global scale, the EdTech market is experiencing rapid growth, with projections suggesting its valuation will exceed $600 billion by the year 2027 (HolonIQ, 2022). Platforms such as Khan Academy, Duolingo, and BYJU'S have fundamentally transformed the manner in which learners' access and engage with educational content—progressing towards more autonomous, gamified, and multimedia-enriched models.

In Nigeria, the offline access capability of uLesson and its alignment with the West African curriculum exemplify a dedication to contextually relevant learning experiences. Edukoya's incorporation of AI-driven practice assessments and real-time tutoring showcases the capacity of technology to furnish personalized academic support to learners irrespective of their geographical location. These innovations highlight the transformative potential of EdTech—characterized by flexibility, scalability, cost-effectiveness, and personalization.

However, the paradox resides in the inconsistent access to these innovations. While digital learning is rapidly advancing in urban areas and among affluent learners, rural and low-income communities continue to contend with fundamental access challenges. In regions of Northern Nigeria, where internet connectivity is sparse and electricity is often unreliable, even the most well-conceived EdTech solutions remain unattainable. This paradox is also observable on a global scale: in Appalachian communities within the United States or in various rural locales in Bangladesh, access to advanced technological tools remains significantly limited.

Moreover, the prevalence of tools designed in Western contexts presents significant challenges regarding cultural suitability. Educational technology solutions frequently embody inherent assumptions pertaining to language, pedagogy, and learner behaviour that diverge from local customs and realities. For instance, speech recognition technologies may struggle to accurately comprehend indigenous accents, and artificial intelligence tutors that have been trained on datasets devoid of African representation may misinterpret learner responses, potentially distorting learning analytics and obstructing educational advancement.

Thus, notwithstanding the considerable promise presented by educational technology, actualizing its comprehensive potential necessitates the confrontation and rectification of its fundamental paradoxes. Inclusive innovation must acknowledge not solely technological progression but also the socio-cultural and infrastructural circumstances that dictate who reaps benefits—and who is marginalized.

Bridging the Digital Divide: The Access Challenge Connectivity GapsDependable internet connectivity serves as the cornerstone of digital education. Nevertheless, fewer than 30% of educational institutions in Africa possess internet access (UNESCO, 2023). In Nigeria, particularly in the North-East region, insecurity and inadequate infrastructure further impede digital connectivity. Satellite broadband initiatives such as Starlink and mesh Wi-Fi networks like BRCK in Kenya are providing scalable solutions for remote locales. In the Philippines, the DepEd Commons initiative faced significant challenges in reaching Mindanao due to infrastructural deficiencies. In Nigeria, governmental initiatives such as the National Broadband Plan and Lagos State's Smart City initiative are commencing efforts to rectify these deficiencies, aspiring to deliver public Wi-Fi and digital resources to educational institutions.

Device Disparity

Access to technological devices constitutes another considerable impediment. In Brazil, the "Computador para Todos" initiative subsidized laptops for students. In Nigeria, collaborative efforts between public and private sectors, exemplified by the Zinox-Government partnership, endeavor to provide affordable devices to educational institutions. Shared device models, such as tablet libraries in Ghana and solar-powered DigiTruck kiosks in Tanzania, are also enhancing access to devices. In Nigeria, local initiatives—such as tablet libraries in public schools within Lagos and mobile learning kiosks in Abuja—are contributing to the mitigation of the device disparity. Solar-powered learning hubs, piloted in rural Kaduna, are facilitating digital education in areas where electricity supply is inconsistent.

The Equity Imperative: Bias-Aware and Personalized Learning

Algorithmic Bias

While AI-driven educational technology has the potential to customize learning experiences, it may also perpetuate biases if inadequately regulated. Research conducted by MIT (2023) elucidates how speech-to-text software frequently misinterprets non-Western names and accents. For instance, a student who speaks Yoruba and utilizes a Western-accented AI application may experience difficulties with pronunciation recognition, thereby affecting their self-esteem and educational outcomes. Addressing these biases necessitates the utilization of inclusive datasets and the regular auditing of AI systems. Nigerian educational technology enterprises, such as Tuteria, are striving to ensure that their platforms are culturally and linguistically inclusive, incorporating local languages and dialects.

Neurodiversity and Special Needs

Inclusive design principles are vital for accommodating learners with disabilities. Tools such as Microsoft's Immersive Reader, Bookshare, and Kurzweil Education are enhancing content accessibility for students with visual, cognitive, and motor impairments. In South Africa, eLimu integrates sign language and voice commands to support deaf learners. In Nigeria, the Inclusive Education Project in Oyo State is piloting educational technology applications that utilize Yoruba and sign language to assist students with hearing impairments, while organizations such as the Nigerian Society for the Blind are advocating for the development of more accessible digital content.

Personalized Learning

Adaptive learning platforms such as DreamBox in the United States and Squirrel AI in China leverage real-time data analytics to customize educational pathways, thereby enhancing learner autonomy and engagement. In Nigeria, platforms such as uLesson and Edukoya utilize artificial intelligence to develop individualized study plans and assessments, thereby facilitating students' preparation for national examinations like WAEC and UTME. These educational tools are particularly beneficial for students who are managing the dual demands of academic responsibilities and familial or occupational obligations—a prevalent circumstance within many Nigerian and broader African households.

Technological Innovations Across Learning Settings

K-12 and Higher Education

Artificial intelligence tutors, including ChatGPT, Squirrel AI, and Duolingo Max, furnish conversational and inquiry-based learning experiences. Virtual laboratories such as Labster, PhET, and PraxiLabs empower students to perform scientific experiments remotely, thus alleviating the necessity for costly laboratory equipment. Within Nigeria, uLesson's video tutorials and assessments are meticulously aligned with national curricula, while gamification instruments such as ClassDojo and Minecraft Education are increasingly being implemented in educational institutions in Lagos to enhance student engagement. Predictive analytics employed at Georgia State University in the United States are instrumental in mitigating achievement disparities, while analogous data-driven methodologies are currently undergoing pilot testing at the University of Ibadan.

Workplace Learning and Reskilling

Microlearning platforms such as LinkedIn Learning, Skillshare, and Nigeria's uLesson decompose content into modular and easily comprehensible formats. Augmented reality and virtual reality training tools—exemplified by PwC's VR-based leadership modules—have demonstrated a reduction in training duration by 40% (PwC, 2022). In Nigeria, banking and technology enterprises are employing VR-based training modalities to enhance employee skill sets, while local universities are tailoring learning management systems like Moodle to accommodate local requirements. Utiva, a Nigerian EdTech startup, offers digital skills boot camps for young professionals, contributing to the alleviation of the employability gap.

EdTech Entrepreneurship: Catalysing Innovation and Equity

Investment Trends

Global investments in EdTech reached $10.6 billion in the initial half of 2023, with a noticeable increase in emphasis on impact-oriented startups (HolonIQ, 2022). International investment funds such as Reach Capital and the Omidyar Network are providing support to startups within emerging economies. In Nigeria, entities such as RiseVest and the Bank of Industry are enabling early-stage investments in local EdTech initiatives, while the Tony Elumelu Foundation offers grants and mentorship opportunities for African entrepreneurs.

Notable Startups

Africa and Beyond:

M-Shule (Kenya): M-Shule represents Africa's pioneering adaptive, SMS-based learning management platform, specifically engineered to reach learners residing in low-income and rural areas devoid of internet connectivity. It disseminates tailored lessons, quizzes, and assessments via basic mobile phones, thereby facilitating accessible education to over 200,000 learners. This innovative model capitalizes on the prevalence of mobile technology to surmount connectivity challenges.

Ubongo (Tanzania): Ubongo develops captivating educational animated series such as "Akili and Me" and "Ubongo Kids," which are broadcast across more than 40 African nations. These animated programs are strategically designed to foster numeracy, literacy, and essential life competencies through entertaining and culturally resonant narratives, thereby reaching millions of children through television and radio.

PrepClass (Nigeria): PrepClass is an online tutoring platform in Nigeria that adeptly connects students with qualified tutors for national assessments including WAEC, NECO, and JAMB. By establishing a digital marketplace for educational services, it not only enhances students' academic performance but also generates substantial employment opportunities for thousands of young educators nationwide.

uLesson (Nigeria): uLesson delivers an extensive array of video lessons, assessments, and academic assistance that are meticulously synchronized with the West African educational frameworks. A salient characteristic is its provision for offline accessibility, which empowers students situated in regions with limited internet connectivity to download educational materials and engage in learning without the necessity for continuous online access, thereby enhancing the accessibility of quality education.

Edukoya (Nigeria): Edukoya represents an artificial intelligence-driven examination preparation platform specifically designed for secondary school students in Nigeria. It offers individualized practice examinations, comprehensive performance analytics, and immediate access to expert educators, thereby enabling learners to prepare efficiently for competitive national assessments such as WAEC and UTME.

Tuteria (Nigeria): Tuteria functions as a peer-to-peer platform that facilitates the connection of learners with tutors across a diverse spectrum of academic and vocational competencies. Its focus on local relevance ensures that learners can identify tutors who comprehend their distinct educational contexts and cultural intricacies, thus promoting more effective and relatable learning experiences.

FlexiSAF (Nigeria): FlexiSAF supplies an all-encompassing school management software and digital educational content, particularly aimed at enhancing public schools in Northern Nigeria. Their solutions assist educational institutions in optimizing administrative processes and assimilating digital resources into their pedagogical practices, thereby contributing to the modernization of education in underserved areas.

Global Examples:

BYJU’S (India): BYJU’S ranks among the largest personalized learning applications globally, boasting a substantial user base. It concentrates on K-12 education and examination preparedness, delivering captivating video lessons, interactive activities, and adaptive learning trajectories across a multitude of subjects.

DreamBox (US): DreamBox serves as an adaptive mathematics platform primarily designed for primary and secondary students in the United States. It employs sophisticated adaptive learning technology to customize the curriculum and instructional methodologies to align with each student's distinct learning preferences and pace, thereby providing tailored mathematics education.

Squirrel AI (China): Squirrel AI constitutes an AI-driven adaptive learning platform in China, with a primary emphasis on K-12 education. It leverages advanced algorithms to discern student learning deficiencies and deliver highly individualized instruction, aiming to bridge achievement gaps and enhance academic performance.

Labster (Denmark): Labster offers virtual science laboratories utilized in over 70 countries globally. These immersive simulations enable students to undertake complex and frequently hazardous experiments within a safe virtual setting, mitigating the necessity for costly physical apparatus and rendering science education

Collaborative Models

International:

Atal Innovation Mission (India): This government-sponsored initiative in India facilitates the establishment of Atal Tinkering Labs in over 10,000 educational institutions nationwide. These laboratories are meticulously designed to cultivate innovation and creativity among students from an early age, offering them experiential learning opportunities in STEM disciplines and bolstering the development of local EdTech startups by fostering an environment conducive to nurturing future innovators.

UNICEF Innovation Fund: The UNICEF Innovation Fund allocates equity-free financial resources to nascent, open-source technological solutions that aspire to enhance the welfare of children in marginalized communities worldwide. This fund endorses pioneering EdTech initiatives that tackle pressing educational challenges, particularly in developing nations, by advocating for scalable and impactful solutions.

Global Partnership for Education (GPE): The GPE constitutes a multi-stakeholder coalition and funding mechanism dedicated to assisting low-income nations in cultivating resilient educational frameworks. Through collaborative research, policy discourse, and innovation, the GPE aids these nations in fortifying their educational infrastructure, enhancing learning outcomes, and effectively incorporating technology.

Nigeria:

Lagos State EdTech Policy: The Lagos State Ministry of Education, in collaboration with various EdTech startups, is proactively implementing pilot programs for digital tools and solutions within public schools throughout the state. This initiative underscores the importance of comprehensive teacher training programs designed to equip educators with the requisite skills for effective technology integration, coupled with substantial investments in digital infrastructure to facilitate widespread adoption.

EkoDigital School: EkoDigital School represents a program that incorporates digital learning within the public-school curriculum in Lagos State. It emphasizes the establishment of smart classrooms outfitted with contemporary learning technologies and the execution of extensive teacher upskilling initiatives to ensure educators are adept at utilizing digital tools to enhance pedagogy and learning.

Nigerian EdTech Summit: The Nigerian EdTech Summit is an annual gathering that functions as a vital forum uniting key stakeholders from governmental bodies, the private sector, and non-governmental organizations (NGOs). Its principal aim is to promote cross-sector collaboration, disseminate best practices, and stimulate policy dialogues intended to expedite the growth and efficacy of EdTech solutions across Nigeria.

Challenges to Inclusive EdTech Deployment

Obstacles to the implementation of inclusive EdTech encompass inadequate data privacy regulations, constrained financial resources, scalability challenges, and a deficiency in cultural adaptation of imported tools. For instance, digital ethics modules developed in Western contexts may not align with the experiences of Nigerian students. Furthermore, linguistic diversity presents another challenge, as a significant portion of digital content is only accessible in English or other dominant languages, thereby excluding millions of learners who communicate in indigenous languages. Additionally, gender disparities persist, with girls in certain regions encountering heightened obstacles to accessing digital education.

Strategic Recommendations

Expand digital infrastructure: Allocate resources towards nationwide broadband and electricity initiatives, prioritizing rural and underserved communities. Foster innovation hubs: Create centres dedicated to EdTech research and development within public universities and colleges of education. Enforce AI ethics and data privacy: Formulate and implement standards aimed at safeguarding learners' data and ensuring equity in AI-driven tools. Promote cross-sector collaboration: Stimulate partnerships among government entities, startups, NGOs, and academic institutions to amplify inclusive solutions. Localize content: Generate digital learning resources in indigenous languages and culturally pertinent formats. Support teacher training: Facilitate continuous professional development opportunities for educators to proficiently integrate EdTech into their instructional practices.

Conclusion: Reimagining the Learning Ecosystem

The domain of EdTech entrepreneurship offers a profound opportunity to humanize and democratize educational practices on a global scale, particularly within the context of Nigeria. By emphasizing principles of accessibility, adaptability, and equity, technological advancements possess the potential to empower every learner—irrespective of geographic location, personal identity, or socio-economic standing—to flourish. The actualization of this aspirational vision necessitates persistent investment, innovative policy frameworks, and collaborative initiatives among all relevant stakeholders. Collectively, we have the capacity to construct inclusive learning ecosystems wherein technology significantly enhances educational opportunities for all individuals.

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REVOLUTIONISING AFRICAN ENTREPRENEURSHIP EDUCATION THROUGH SMART TECHNOLOGY INTEGRATION: LESSONS FROM SCHOOLS OF SPECIALISATION (SOS)

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Abstract
Entrepreneurship is widely recognised as a key catalyst for economic growth, job creation, and innovation - especially in Africa, where a youthful population and rising unemployment highlight the urgent need for education reforms that leverage technology to address these challenges. This position paper advocates the use of Situated Learning Theory as a guiding approach to entrepreneurship education, exploring how its alignment with smart technology can transform learning by anchoring it in authentic, collaborative, interdisciplinary engagement and contextually relevant settings. Through a critical review of existing literature and emerging models from South Africa, Nigeria, Botswana and Kenya, the paper outlines a framework for embedding educational technology into entrepreneurship curricula across schooling and post schooling, tailored to Africa's socio-economic realities.

Key words: entrepreneurship education, smart technology, interdisciplinary collaboration

Introduction

Entrepreneurship education (EE) refers to the structured teaching and learning processes designed to equip individuals with the knowledge, skills, attitudes, and competencies needed to identify opportunities, create value, and start or manage a business (Boocock et al., 2009; Ndedi & Ijeoma, 2008). Ideally, EE should extend beyond business theory to include experiential learning, opportunity recognition, budgeting, and problem-solving, often aimed at addressing local economic challenges and fostering innovation-driven self-employment (Chimucheka, 2014; du Toit & Gaotlhobogwe, 2018). With such skills, the scourge of unemployment that is concerning to several African governments would be resolved, more so that there are tools that can help achieve this on a scale, timeously and efficiently. This is particularly evident in how digital technology has proven to be a powerful enabler of diverse entrepreneurial opportunities, offering versatile functions that support innovation and efficiency. With the advancement of the internet, software, and hardware, technology now enhances human productivity to such an extent that it appears to operate with a level of autonomy and speed beyond human capacity - characteristics that have led to it being described as smart.

Smart technology in education encompasses digital tools and platforms such as mobile learning applications, virtual simulations, artificial intelligence, and virtual incubators - that enable personalised, scalable, and interactive learning experiences (Valerio et al., 2014; Von Maltitz & Van der Lingen, 2022). Within entrepreneurship education, smart technology acts as both a delivery mechanism and a learning ecosystem, allowing learners to engage in real-time feedback, simulate business scenarios, and access mentorship and entrepreneurial resources regardless of geographic location. The challenge though is that most of the African population does not or cannot own these powerful devises. If they do, they are mainly using them for communication, and this is due to constraints that could be overcome if entrepreneurship education was given the attention it deserves.

Africa is home to one of the fastest-growing youth populations in the world, with nearly 60% of its population under the age of 25. This demographic shift presents both a massive opportunity and a looming crisis. While young people are a key asset for innovation and labour, the continent's economic structures have struggled to absorb this rapidly growing workforce. As of 2023, sub-Saharan Africa continued to face some of the highest youth unemployment and underemployment rates globally, with millions of young people stuck in informal, precarious, or low-wage jobs (International Labour Organization, 2022). With youth unemployment persistently high - exceeding 50% in South Africa and marked by widespread underemployment in countries like Nigeria (World Bank, 2023; ILO, 2022), traditional educational pathways are proving insufficient.

Compounding the problem is the fact that traditional sectors like agriculture and mining once dependable job creators, are no longer able to absorb new entrants at the same scale. The influx of technology in these industries seems to have worsened the situation as jobs have become obsolete. For instance, manual land and tunnel survey work by drone surveying and GPS mapping in mining and manual labour to operate irrigation systems with smart irrigation systems. Simultaneously, rapid urbanisation, fragile infrastructure, and limited industrialisation have stifled formal job creation in both urban and rural areas (African Development Bank, 2021). Even educated youth, including university graduates, face what economists call "skills mismatch"—a situation where what is taught in schools does not match labour market demands (UNDP, 2020).

This has intensified the need for entrepreneurship as a viable and scalable pathway to economic participation. Entrepreneurship is not only seen as a source of self-employment but also as a solution for creating jobs for others. However, many aspiring entrepreneurs lack the ecosystem support, access to markets, and training needed to thrive (Malecki, 2018) and yet, there is abundance of information online and through collaboration and mentorship that can easily occur online and with smart technology. This makes the case for transforming education systems, and particularly entrepreneurship education through smart technology more urgent than ever.
One of the most promising interventions lies in entrepreneurship education (EE), especially when it is intentionally supported by smart technology. By enabling access to entrepreneurial learning, mentorship, and digital marketplaces, it offers a scalable way to empower youth economically (Orji & Perumal, 2025). However, for this to be truly effective, African education systems must become more responsive to socio-economic realities, using technology not just as a delivery tool, but as a platform for situated learning, where learners solve real-world problems with local relevance (Von Maltitz & Van der Lingen, 2022).

This position paper employs a conceptual and discursive methodology to critically examine the integration of smart technologies into entrepreneurship education within Africa. It draws on scholarly literature with examples that help support its arguments. The paper adopts Lave and Wenger's (1991) situated learning theory as a lens for analysing insights on entrepreneurship education in South African Schools of Specialisation (SoS) and in African countries such as Botswana, Kenya, Nigeria that have been employed to curb unemployment and promote entrepreneurship. Rather than relying on empirical data, the paper synthesises diverse sources to build a theoretically informed position that advocates for context-driven, technology-enabled education reform. The goal is to provoke dialogue and inform policy, design, and investment in African EE.

The research question for this paper is, in what ways can the integration of smart technology into entrepreneurship education in Africa reshape learning to meet local and global demands?

Theoretical Lens: Situated Learning Theory

Situated Learning Theory was first introduced by Jean Lave and Etienne Wenger (1991) in their attempt to prove that learning is inherently social and contextual, occurring most effectively when embedded in authentic activities, contexts, and cultures. They propose that, rather than view knowledge as something that can be transferred abstractly in decontextualized classroom settings, the theory emphasizes learning as a social process that occurs through participation in real-life activities within communities of practice (Lave & Wenger, 1991; Wenger, 1998). This conceptualisation of learning offers the potential to support the transformation of African education systems by rooting learning in authentic, context-specific practices, moving away from inherited foreign ideologies toward approaches that reflect local realities and community-based ways of knowing (Mbeteh & Pellegrini, 2022; Okebukola, 2020). This opens opportunities for innovation in addressing pressing social challenges such as joblessness that persist even among qualified individuals across the continent, by engaging learners in meaningful, real-world problem-solving within their own communities (Mncwango & Adanlawo, 2025; World Bank et al., 2023).

A key concept in this theory is Legitimate Peripheral Participation (Lave & Wenger, 1991) which refers to the process by which learners become part of a community and gradually move from peripheral involvement to full participation. Learning, in this sense, is about becoming a practitioner not just acquiring knowledge but engaging in the practices and social relations that define a professional or vocational identity (Lave & Wenger, 1991, p. 29) that currently operates through digital technology for efficiency and effectiveness. Becoming a practitioner or expert in an area is attained over time (Winch, 2010) and introducing it across schooling is bound to increase entrepreneurial capacity in school leavers and graduates.

Situated learning is supported by a growing body of work in education and professional development. Brown et al., (1989) argue that cognition is fundamentally situated - that is, shaped by the tools and social context in which it develops. In this case, smart technology that most entrepreneurs rely on in this digital era becomes an important tool to integrate in today's education if it will be relevant. Herrington & Oliver (2007) emphasize the value of authentic learning environments (Elkington & Chesterton, 2025), which engage learners in tasks that mirror real-world practices and promote higher-order thinking.

Applying situated learning to education entrepreneurship in Africa presents a compelling strategy for addressing local economic challenges while transforming traditional models of schooling. Entrepreneurship education often struggles to make an impact when taught as theory alone, detached from the local realities learners face. Situated learning offers more relevant, practice-based alternatives such as the following:

Learning in Authentic Contexts

Learners can engage in real entrepreneurial projects in their communities. For instance, they can run small cooperatives, build digital services, or solve local problems that they may have been exposed to in their learning environment. Contextualising learning in these environments serve as living laboratories for entrepreneurial learning (Hindle, 2007).

Mentorship and Apprenticeship Models

Drawing on the principle of Legitimate Peripheral Participation (LPP), experienced entrepreneurs or community leaders can act as mentors, allowing learners to develop entrepreneurial skills through guided participation (Shirindi, 2024). This is especially powerful in African contexts where informal learning and oral traditions are significant modes of knowledge transmission. Smart cell phones and similar technologies can facilitate synchronous communication that can facilitate mentorship and networks and make entrepreneurship thrive.

Community-Driven Innovation

Communities of practice can form around shared entrepreneurial goals. For instance, groups of learners, educators, and local business owners can collaborate through social media to co-create sustainable ventures. This reinforces social learning (Al Issa, et al., 2025) while building local capacity (Wenger et al., 2002).

Building Entrepreneurial Identity

Beyond skills, situated learning helps learners form entrepreneurial identities as they begin to see themselves as contributors to economic and social transformation (Rae, 2005) which can be facilitated by smart technology. In African education, this shift is vital for empowering youth and fostering innovation that is grounded in local knowledge systems.

Africa’s economic development continues to be shaped by structural inequalities, dependence on imported goods, and a largely informal economy and yet, its education systems do not adequately prepare its graduates for responding to these challenges. In other words, learning experiences are often not situated in their lived experiences. As a result, despite abundant natural resources, many African countries struggle to develop robust manufacturing sectors that transform local materials into value-added products (Bhorat et al., 2016). A key constraint is the lack of entrepreneurial competence - practical, technical, and strategic skills necessary to launch and sustain productive enterprises that should be acquired in classrooms and advanced in lecture rooms. Entrepreneurship education (EE), when strategically delivered through smart technology, offers a way to build these competences at scale and in context.

Regrettably, traditional entrepreneurship education (EE) in Africa often prioritises theoretical knowledge that is often not situated in local contexts thus, limiting its impact on learners' ability to launch real-world ventures (Kamovich & Foss, 2017). EE curricula frequently lack alignment with local economic contexts, failing to address the informal economy or resource-based innovation common across the continent (Chimucheka, 2014). For instance, at school level, South Africa’s Continuous Assessment Policy Statement (CAPS) omits explicit references to entrepreneurship, despite its focus on problem-solving in technology subjects (du Toit & Gaotlhobogwe, 2018). However, a study of the more detailed specifications of the current Technology (the subject) curriculum (Du Toit & Gaotlhobogwe, 2018) indicates that very few aspects of entrepreneurship education are dealt with in South Africa. This indicates a lack of alignment of two aspects of the intended curriculum, that is, between the rationale and the content in the curriculum (Thijs & Van den Akker, 2009). At university level, the same gap exists where EE is typically confined to business schools, with limited interdisciplinary collaboration or experiential learning opportunities (Price & Ronnie, 2021) that can prepare learners for authentic work experiences that thrive on drawing from diverse sources. Much can be learned from several African countries (Botswana, Kenya and Nigeria, among others) that have effectively included and embedded entrepreneurship education in the curricula of Technology and vocational subjects in order to reduce unemployment (Du Toit & Gaotlhobogwe, 2018).

Botswana stands out for embedding entrepreneurship principles directly into its junior secondary school Technology curriculum, rather than treating it as a standalone subject. This aligns with the argument by Tawodzera et al. (2019) that integrating entrepreneurship into existing practical subjects can help contextualise learning and encourage real-world application. Learners in Botswana work on design projects, develop products from local resources, and simulate basic business processes like costing and marketing - thus learning by doing. While digital infrastructure remains uneven, the approach reflects a commitment to situated and experiential learning, aligning with the call for curriculum reform in Africa

Nigeria's federal mandate that all tertiary institutions must offer entrepreneurship education has helped shape a policy landscape conducive to innovation. As noted in Amadi-Echendu (2016), Nigeria's model is cited as an example of deliberate policy-driven integration, which South Africa and other African countries could learn from. Beyond policy, Nigeria is also home to a dynamic EdTech ecosystem. This environment supports compulsory EE through blended learning, digital platforms, and youth-led incubation programmes, which mirror the hands-on, multi-disciplinary approaches advocated by Gwija and Eresia-Eke (2014).

Kenya's use of mobile platforms for entrepreneurial training represents an accessible, scalable model of EE. This concept is echoed in Dana et al. (2021) which stresses the importance of informal digital access for youth empowerment through entrepreneurial education. Initiatives like Kenya's Ajira Digital Programme equip youth with gig-economy skills while emphasising digital literacy and entrepreneurship. These efforts speak to the urgency of creating context-sensitive, mobile-first educational experiences, a theme also emphasised by Gamede & Uleanya (2019) where the importance of informal and digitally supported learning is foregrounded.

It is baffling that after these success stories, the latest statistics from ILO Modelled Estimates database (2025), a World Bank Group reports the following 2024 youth unemployment rate for Botswana – 43,9% and South Africa – 60.9%. Kenya – 11.9% and Nigeria – 5.1% have lower rates and this is due to the successful digital technology programmes targeted at creating youth employment that the 2 countries have benefited from. The 3 Million Technical Talent (3MTT) in Nigeria for example, combines online learning in digital skills (AI, software, data science, freelancing) with hands-on, community-supported practice. It is designed to position youth as creators in a digital economy (World Bank Group, 2022). On the other hand, Kenya's youth unemployment was alleviated by the Ajira Digital project that connected youth to online and marketplaces, enabling self-provision through platforms beyond the limitations of formal job availability.

There is evidence that the utilisation of technology has potential to reach many young people and orient them to entrepreneurial skills. This study seeks to examine how African countries such as South Africa can leverage technology-integrated entrepreneurship education to address high unemployment rates.

Developing Entrepreneurial Competences Through Smart Technology

Entrepreneurial competences such as opportunity recognition, budgeting, and design thinking are critical for value creation in African economies. Technology-enabled learning platforms can foster these skills through interactive tools, simulations, and community-based projects.

Smart technology, in the context of entrepreneurship education (EE), refers to the use of digital tools such as mobile learning apps, virtual simulations, AI-driven platforms, and virtual incubators to enhance how learners acquire entrepreneurial skills. These tools enable flexible, scalable, and interactive learning experiences tailored to diverse environments (Valerio et al., 2014). For instance, virtual simulations allow students to experiment with budgeting or customer feedback without real-world risk, while AI tools can offer personalised learning paths based on a learner's pace, interest, and progress. Virtual incubators like those piloted in Kenya's iHub or Nigeria's Co-Creation Hub—offer learners exposure to mentors, funding advice, and ideation workshops online. Such support contributes to the contextualisation of knowledge and skills and promotes LPP (Lave and Wenger, 1991).

Among the various affordances of smart technology, mobile learning stands out as both highly accessible and widely utilised. With mobile phone penetration exceeding 80% in sub-Saharan Africa, even learners in rural areas can access entrepreneurship content. Platforms like mCourser and Eneza Education have demonstrated the feasibility of delivering business and financial literacy via SMS and web-based interfaces. These models are highly scalable and address key barriers such as lack of broadband or formal devices (UNESCO, 2023). In the African classroom context, low-cost platforms such as WhatsApp and YouTube are already being repurposed for learning. For instance, teachers in South Africa and Ghana use WhatsApp groups to distribute business case studies and voice notes, while YouTube tutorials are used to teach practical entrepreneurship skills like product packaging and digital marketing. These platforms improve access and real-time engagement (Mpungose, 2020), especially in rural or low-resource settings where traditional infrastructure is limited (Von Maltitz & Van der Lingen, 2022).

Learning Management Systems (LMSs) like Moodle, Sakai and Kolibri are being adopted across African institutions for entrepreneurship content delivery. These systems offer modular learning paths, embedded assessments, and forums for peer interaction, creating a more structured learning environment than ad-hoc online videos. Kolibri, for instance, has been implemented in resource-constrained communities and supports offline access that is critical in areas with limited internet connectivity (Groeneveld et al., 2021). These platforms are problematic because they are proprietary and only accessible through formal education institutions, leaving out many youths who lack the means to register. In this context, Open Educational Resources (OER) represent a vital intervention that should be adopted and implemented at the national level to ensure all youth are included. Participation in these free, editable, and shareable materials empower educators to localise global content for African learners. The African Storybook Initiative the OER Africa platform run by the South African Institute of Distance Education (SAIDE) have curated toolkits that can be easily integrated into entrepreneurship curricula. These resources reduce dependence on expensive copyrighted textbooks and allow for rapid curriculum adaptation (Dabula et al, 2024).

Artificial Intelligence (AI) is increasingly being integrated into educational systems to personalize learning experiences, making it an especially powerful tool for adapting Open Educational Resources (Tlili & Burgos, 2024) that were not originally designed with African contexts in mind. As noted by OER Africa, AI can automate the localization and adaptation of content such as translations, culturally relevant examples, and interactive exercises, thus facilitating the efficient and contextually appropriate deployment of OER at scale. In entrepreneurship education, AI-powered tools can recommend learning resources, simulate investor pitches, or offer automated feedback on business plans. The challenge with using these tools is that teachers have not been trained on how to use them. Secondly, teachers have not been adequately trained to use AI to adapt the local curriculum in ways that support this important agenda of entrepreneurship education (EE).

Virtual simulations and gamified platforms provide dynamic and risk-free environments where learners can practice starting and managing businesses. SimVenture, BizInnovator, and GoVenture are examples of simulation tools that allow users to model business operations, make decisions, and receive immediate feedback. These simulations align with Kolb's experiential learning theory, which posits that learners understand concepts better when they engage in hands-on, reflective experiences. Emerging evidence shows that integrating simulations into African entrepreneurship courses improves learners' critical thinking and decision-making skills (Ssemambo & Balunywa, 2022). Augmented Reality (AR) and Virtual Reality (VR) provide immersive learning experiences that can simulate real-world entrepreneurial environments, allowing learners to engage with content in ways that closely mirror actual work settings. Though still limited in implementation due to cost, pilot projects in Kenya and Nigeria have used VR to simulate product development and retail environments, giving learners a sense of space, customer interaction, and decision-making without physical overheads.

Another powerful affordance is collaborative cloud-based tools, which foster real-time communication and co-creation. Tools like Google Workspace and Microsoft Teams are already used by African universities to facilitate cross-disciplinary entrepreneurship projects. These tools enable learners from different specialisations such as Information Technology (IT), agriculture, and marketing to collaboratively build viable business solutions. A study by Udanoh & Zouria (2023) emphasises the role of digital collaboration in fostering innovation in resource-constrained contexts. Besides being a valuable attribute in entrepreneurship (Lin & Maruping, 2022), there is 'the intellectual synergy of many minds coming to bear on a problem, and the social stimulation of mutual engagement in a common endeavour' (Vali, 2023, p.127). In addition, operating within such communities offers the advantage of accessing established networks and partnerships such as the Tshimologong Digital Innovation Precinct in Johannesburg and the Innovation Hub in Pretoria. These platforms enable both emerging and established entrepreneurs to address gaps and challenges in their own businesses and those of others, while also providing access to the digital resources needed to develop their products (Abubakre et al., 2021).

On the other hand, content creation platforms like YouTube, TikTok, and Instagram are often overlooked in formal curricula, but they offer real-world entrepreneurial experience. Learners can use these platforms to launch micro-brands, test business ideas, and engage with audiences. South African youth have used TikTok to showcase homemade products, leading to online businesses - highlighting how digital storytelling can generate income and build business skills (Maree, 2023). eCommerce and mobile payment tools like Jumia, Yaga, M-Pesa, and SnapScan provide a full entrepreneurial ecosystem where learners can prototype and sell real products. These platforms support transaction management, customer engagement, and business analytics. In university programmes, students are encouraged to integrate these platforms into their capstone projects, simulating full product cycles (UNDP South Africa, 2023).

Financial inclusion technologies such as mobile banking, budgeting apps, and blockchain-based microfinancing equip learners with practical money management tools. For instance, South Africa's Youth Employment Service (YES) incorporates mobile-based financial tools to help learners track spending and savings as they complete entrepreneurship modules (Lottan &

Scheepers, 2024). These technologies bridge the gap between theory and practice by immersing students in real-world financial behaviours.

A Model for Situated Entrepreneurship Learning: Schools of Specialisation

The Schools of Specialisation (SoS) in the Gauteng Province, South Africa offer a unique model that integrates some of these affordances within the public school system. The SoS initiative was launched by the Gauteng Department of Education (GDE) to respond to systemic education inequalities and to align schooling with the province's economic development goals. It focused on areas like engineering, mathematics, commerce, and ICT, these schools use industry partnerships and work-integrated learning to expose learners to the entrepreneurial potential of their fields (GDE, 2020). SoS leverages smart classrooms, access to digital content, and project-based learning to enable practical skill development and entrepreneurial mindset formation (Gauteng, 2021). Learners can engage in digital exercises that require them to solve real-world problems, prototype ideas, and track costs—skills that mirror entrepreneurial practice (McGuigan, 2016).

Gauteng's Schools of Specialisation (SoS) offer a progressive framework for embedding entrepreneurship education within authentic learning environments. These schools are purpose-built to align with South Africa's strategic economic sectors - including engineering, commerce, and information technology - by focusing on talent development from the school level. Their curricula are informed by a practical, industry-responsive approach, preparing learners to actively participate in economic growth and innovation (Gwija et al., 2014). There are 7 operating principles that inform the operation of these schools portrayed in Figure 2 below:

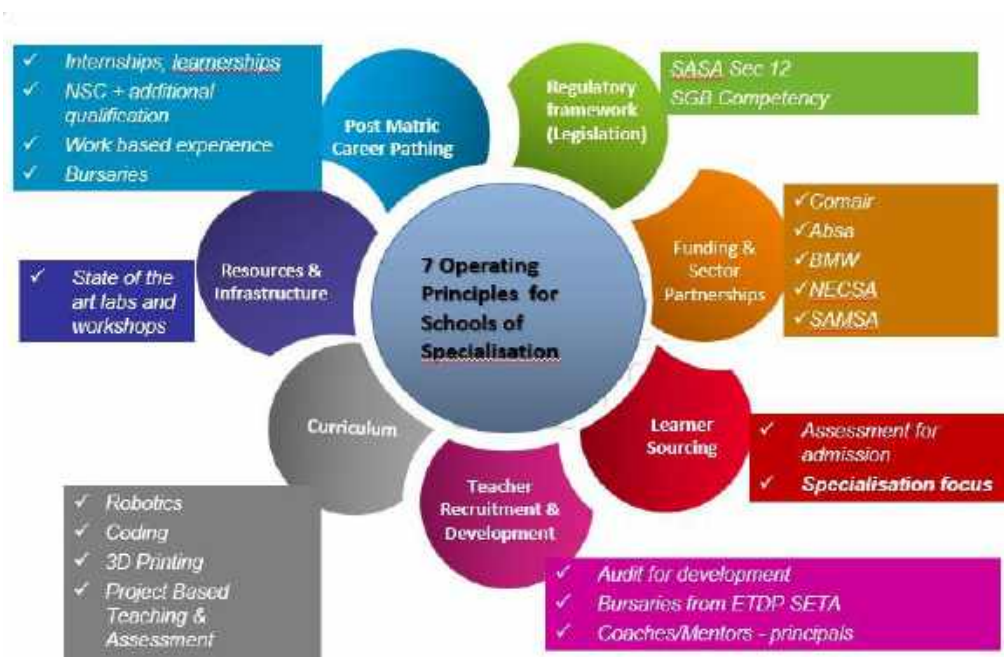

Figure 1: Seven operating principles for SoS
Source: Gauteng Department of Education (2019)

Rooted in the principles of situated learning, SoS create real-world experiences through project-based tasks, entrepreneurial simulations, and direct industry engagement. This mirrors the call for experiential learning strategies found in literature, which emphasise the importance of learning through doing, observing, and reflecting in authentic contexts (Chimucheka, 2014; Mmbengwa et al., 2019). Learners engage in entrepreneurship projects that simulate real market conditions, supported by mentoring and partnerships with local businesses that contribute by sponsoring, partnering and providing mentoring and making clear what it takes to become an expert in the field. This allows them to co-construct knowledge in socially and economically relevant ways.

To facilitate activities related to situated learning, these schools are intentionally located in historically disadvantaged areas, including townships and peri-urban zones. Figure 2 below shows how the schools are distributed within the five industrial corridors in the province.

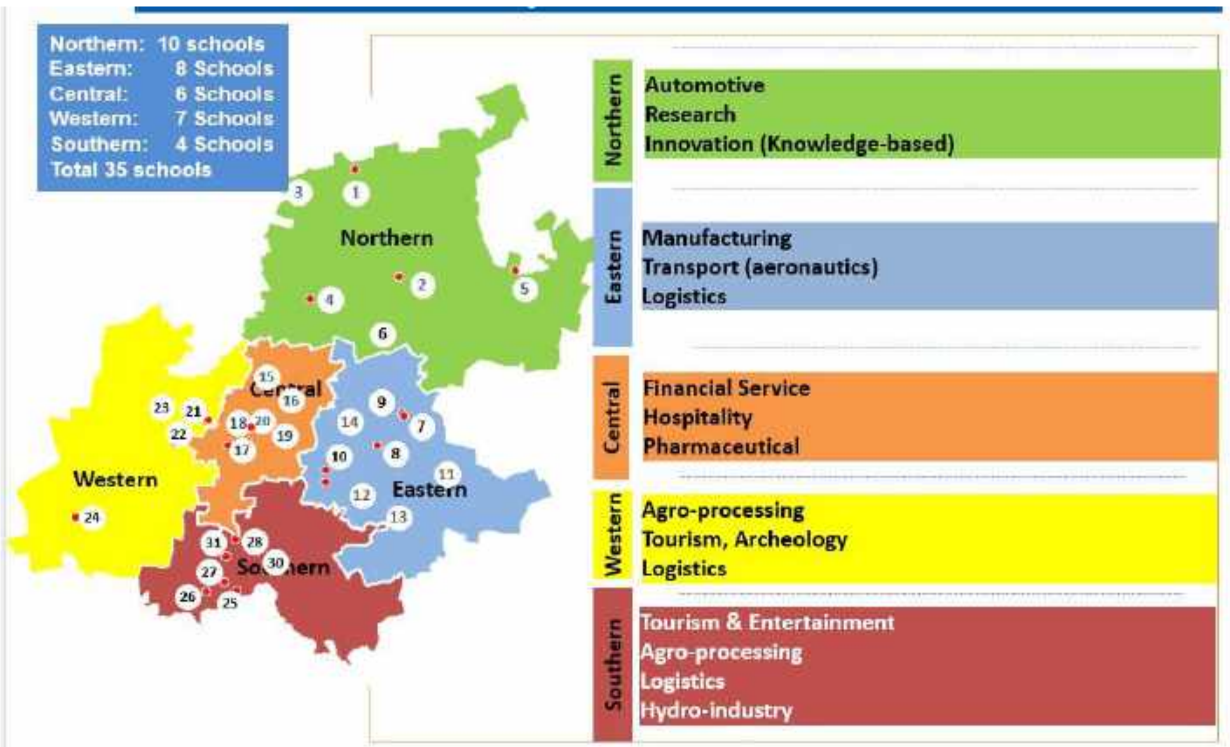

Figure 2: Distribution SoS within the five industrial corridors
Source: Gauteng Department of Education (2019)

Technology plays a pivotal role in the SoS model. Classrooms are equipped with digital infrastructure that supports smart learning such as simulations for business modelling, virtual tours of industry settings, and interactive platforms that teach digital marketing and product design. These tools exemplify the type of smart technology affordances that are increasingly recommended in African entrepreneurship education (Musingafi et al., 2014; Von Maltitz & Van der Lingen, 2022). For example, simulations allow learners to experiment with pricing, logistics, and customer feedback loops, while content delivered through platforms like YouTube supports self-directed learning of practical entrepreneurial skills.

The SoS initiative also presents a valuable model for TVET institutions and universities. Replicating the SoS approach in post schooling could help tackle high youth unemployment by empowering students with skills they can use to create jobs, rather than only seek them (Chimucheka, 2014). Its focus on contextualised, tech-enabled, and industry-integrated learning can be adapted to post-school settings. Entrepreneurship education must respond to local socio-economic realities (McGuigan, 2016; Ndedi & Ijeoma, 2008) and embrace collaboration across disciplines and technologies. What sets the SoS model apart is its deliberate move away from rote and exam-focused teaching toward experiential learning models, also informed by Kolb's theory of learning through experience. Learners do not only receive knowledge but actively construct and apply it through real-world problem solving, project-based learning, and the use of digital tools.

Despite resource constraints, the model's strategic use of low-cost and scalable technologies such as mobile devices, open-source content, and locally driven partnerships that make it suitable for wider adoption across Africa. Rather than waiting for full-scale infrastructure investments, institutions can begin by establishing interdisciplinary entrepreneurship labs, investing in microlearning content, and incentivising partnerships between educators, technologists, and the private sector (Gamede & Uleanya, 2019). This approach reflects the core of entrepreneurial learning: the need to build competence in navigating uncertainty, opportunity recognition, iterative product development, and value creation. These skills cannot be taught theoretically alone; they must be experienced, reflected upon, and refined. SoS schools offer makerspaces, robotics labs, coding bootcamps, financial literacy simulations, and partnerships with local businesses—blending smart technology with practical engagement.

Enriching SoS Model

Although the Schools of Specialisation (SoS) model offers a promising pathway for embedding entrepreneurship education (EE) into the curriculum through the integration of smart technology, it should not be viewed as a one-size-fits-all solution. Its limited national adoption suggests the presence of structural and contextual barriers that must be addressed. One key limitation is that the model is heavily industry-specific, often aligned with particular sectors or trades, which may not accommodate learners with entrepreneurial aspirations outside these areas (du Toit & Gaotlhobogwe, 2018). Moreover, there is insufficient evidence on whether such early exposure translates into entrepreneurial outcomes at the tertiary level or results in sustainable business creation, an essential factor in tackling South Africa's high youth unemployment (Price & Ronnie, 2021; StatsSA, 2021). This paper therefore explores three strategic focus areas to address persistent challenges and strengthen the role of the SoS model in transforming entrepreneurship education across African school and university systems

Interdisciplinary Collaboration

In countries facing deep educational inequalities, EdTech entrepreneurs are creating business models that work within infrastructure constraints - such as mobile-first platforms, WhatsApp learning tools, and low-data applications - to serve under-resourced schools and rural communities (Dana et al., 2021). In the African context, Higher Education Institutions (HEIs) are increasingly positioning themselves as entrepreneurial ecosystems that nurture locally relevant innovation. These institutions foster interdisciplinary collaboration and support student-led ventures through incubation hubs and partnerships with industry and government (Amadi-Echendu et al., 2016). In

South Africa, universities like the University of Cape Town and University of the Witwatersrand have introduced innovation labs and EdTech accelerators aimed at addressing learning gaps in township and rural schools. These initiatives reflect a growing commitment by HEIs to enable scalable, context-aware education solutions through research, policy influence, and community partnerships (Tajpour et al., 2020). To reach those who have been excluded by the formal system, initiatives like the ones mentioned above can play a crucial role, but they must be fully funded to ensure free and equitable access.

The transformation of entrepreneurship education cannot rest solely on the shoulders of Ministries of Education. Instead, African states must build innovation clusters where universities, EdTech entrepreneurs, policymakers, industry, and civil society co-create solutions. For instance, business faculties could work with computer science departments to develop mobile apps for financial literacy in rural schools. Agricultural colleges could collaborate with software developers to prototype market-access tools for young agri-preneurs. These interdisciplinary, cross-institutional models of curriculum and technology development reflect a systems-thinking approach needed for scalable impact.

The current scarcity of infrastructure should be a catalyst for creativity, not a barrier. Low-data platforms, USSD technology, solar-powered tablets, and open-source learning materials offer tangible opportunities for scaling entrepreneurial learning in rural and peri-urban areas. What is needed is not more tech for tech's sake, but a shared vision, political will, and strategic partnerships.

Building an Entrepreneurial Mindset and Tech Fluency in Teachers

Situated learning depends on teachers' ability to deliver content through practical, interactive, and reflective tasks. This requires specific training in experiential learning methodologies, such as project-based learning, case study analysis, business model canvassing, and digital storytelling. Mmbengwa et al. (2019) argues, teacher professional development should focus on equipping educators to design entrepreneurship tasks that mirror real-world challenges and promote deep, contextualised learning. Using tools like Google Forms for learner surveys, Canva for product packaging design, or iSpring for interactive simulations can help bridge the gap between theory and practice.

To ensure relevance and credibility, teachers must engage with local entrepreneurs, industry experts, and higher education institutions. These collaborations can take the form of guest lectures, mentorship networks, co-designed learning experiences, and exposure visits to businesses and innovation hubs. As seen in the Schools of Specialisation approach, linking classrooms with the world of work enables educators to stay informed about sectoral trends while creating learning opportunities that are grounded in the real economy. Furthermore, partnerships with universities can facilitate ongoing research, teacher training, and resource sharing, especially in the use of educational technology and digital entrepreneurship content (Gwija et al., 2014; Dana et al., 2021).

Open Education Resources (OER)

For entrepreneurship education (EE) to meaningfully contribute to income generation across diverse populations - whether individuals are formally enrolled in education or not, governments must assume an active role in funding and promoting EE through accessible and inclusive formats, such as open educational resources (OERs). OERs have been recognised for their potential to expand access, reduce educational costs, and support lifelong learning (UNESCO, 2019; Hilton, 2016). In this context, it becomes essential not only to enhance teacher competencies in entrepreneurial pedagogy but also to equip educators with the skills to participate in OER creation, adaptation, and dissemination (Sadruddin (2022). Strategic collaboration between educators and industry actors could further strengthen the availability and relevance of EE resources in specialised fields.

Smart technology plays a critical role in supporting the localisation and contextualisation of these resources, enabling educators and practitioners to develop, curate, and deliver content that reflects local realities and opportunities. Such an approach can extend the impact of Schools of Specialisation beyond formal settings, promoting learning across age groups and socioeconomic backgrounds. By enabling the co-creation and wide distribution of context-sensitive EE content, this model aligns with multiple Sustainable Development Goals (SDGs), including Goal 1 (No Poverty), Goal 2 (Zero Hunger), Goal 4 (Quality Education), Goal 8 (Decent Work and Economic Growth), Goal 9 (Industry, Innovation and Infrastructure), and Goal 10 (Reduced Inequalities) (United Nations, 2015). Ensuring that entrepreneurial learning is accessible, adaptable, and inclusive is therefore essential to advancing equitable and sustainable development in African contexts.

Recommendations

Policy Alignment

Governments should embed entrepreneurship education (EE) and technology integration into national education and economic development strategies. This alignment will ensure coordinated efforts across departments, funding streams, and partnerships that support long-term impact.

Scale Proven Models

Regional and national education authorities should adapt and expand successful initiatives like Gauteng's Schools of Specialisation and particularly those from Nigeria and Kenya as they have proven to be effective in promoting entrepreneurship education. These models offer practical blueprints for embedding project-based, tech-enabled learning that is responsive to local industries and socio-economic needs.

Teacher Preparation

Invest in continuous professional development that equips teachers with the skills to deliver experiential, digitally supported entrepreneurship education. This includes training in smart classroom tools, project facilitation, and context-based pedagogies. OER practices should be treated as essential, not optional, as they play a crucial role in realising the impact of entrepreneurship education (EE) in addressing unemployment and promoting social inclusion.

Fund Interdisciplinary Collaboration

Encourage cross-sector partnerships between universities, TVETs, private sector players, and EdTech startups to co-create infrastructure, share expertise, and build innovation hubs that reflect local realities. This collaborative approach is vital to bridge the gap between schooling and sustainable employment.

Invest in Low-Tech Solutions

Rather than relying on high-end infrastructure, education systems should prioritise scalable, low-bandwidth technologies and open educational resources.

Monitor and Evaluate

Establish robust monitoring and evaluation frameworks that leverage data to track progress, identify challenges, and inform continuous improvement. This should include feedback loops from learners, educators, and industry partners to ensure entrepreneurship education remains relevant, responsive, and grounded in local realities. Data-driven insights will help contextualise implementation and guide the refinement of both pedagogy and policy.

By learning from initiatives like Gauteng's Schools of Specialisation, African countries can take concrete, context-sensitive steps toward revolutionising entrepreneurship education through smart technology.

Conclusion

This paper has argued that the integration of smart technology with situated learning offers a powerful pathway for transforming entrepreneurship education (EE) across Africa. Rather than focusing solely on widening access, meaningful reform must prioritise context-rich, practice-based experiences that equip learners with relevant, adaptable skills. By embedding entrepreneurship from school level through to tertiary and post-schooling environments, and enabling interdisciplinary collaboration between education institutions, industry, and EdTech innovators, African countries can build more responsive and inclusive entrepreneurial ecosystems. The Schools of Specialisation in Gauteng demonstrate that this vision is achievable, even within constraints.

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INNOVATING FOR IMPACT: EDTECHPRENEURSHIP AND THE FUTURE OF EDUCATION IN SCHOOL SETTINGS AND THE WORKPLACE

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Abstract

This paper critically examines the interconnected concepts of Education, Innovation, and EdTechpreneurship, emphasizing their significance and transformative potential in school settings and workplaces. Education is defined as a lifelong, tripartite process (informal, non-formal, and formal) aimed at knowledge acquisition, skill development, and character formation. Innovation, while broadly seen as change, is clarified here as an impactful and sustainable transformation addressing specific needs. EdTechpreneurship, the intersection of education, technology, and entrepreneurship, is posited as a key driver of educational innovation that addresses systemic failures in traditional educational models, particularly in Nigeria. Drawing from theoretical frameworks such as Innovation Diffusion Theory, Social Constructivist Theory, and Disruptive Innovation Theory, the paper explores how EdTechpreneurship creates scalable and sustainable solutions through innovative instructional strategies, systems approaches, and collaborative partnerships. It also highlights how EdTech entrepreneurs apply emerging technologies such as AI, AR/VR, gamification, and data analytics to create personalized and accessible learning environments. The discussion identifies four key strategies for impactful innovation through EdTechpreneurship: the systems approach, practical life-oriented teaching methods, enriched educational resources, and stronger linkages between schools and industries. Case studies from Nigeria and across the globe (e.g., uLesson, Tuteria, Snapplify, Ubongo, GoMyCode) demonstrate how EdTech solutions are reshaping learning outcomes and workplace readiness. In school settings, EdTech improves curriculum relevance, accessibility, personalization, and teacher development. In workplaces, it drives upskilling, improves employee productivity, and futureproofs workforce capabilities. Ultimately, the paper advocates for a shift from certificate-focused education to skills-based, innovation-driven learning.

Introduction

The understanding of the term ‘education’ varies and influences its process and productivity among individuals, families, and nations. In Nigeria, before the advent of the colonialism, informal and non-formal education were predominant. While informal education aimed at transferring cultural norms and beliefs to people, the non-formal apprenticeship system focused on skill acquisitions. Education in that era therefore focused on cultural, social, and vocational skills passed down through generations; people learned through observations, apprenticeship, and community participation. Though there was no formally trained teacher, no curriculum, and no certificate, it was functional promoting skills/productivity and morals in accordance with the needs and aspirations of society.

Then came change ‘*innovations’* through the introduction of formal education by the Christian missionaries in the 1840s. Missionaries established schools, primarily to teach reading and writing skills, with the aim of spreading Christianity. This started down-playing informal and non-formal aspects emphasizing literary subjects, certificate acquisition and white-collar jobs neglecting skills and the blue-collars jobs. Therefore, from that period till date, Nigerians perceive *formal education* as simply *education*, and as a means to higher status with little or no manual work. This poor perception of education has continued to influence every attempt at innovations ranging from Colonial Education (1880s) to Universal Primary Education (UPE, 1952), 6-3-3-4 (1980s), Universal Basic Education (UBE, 1999), and today? Where or what are we practicing; 9-3-4? (Achuonye, 2008). Though all these changes meant well, despite huge investment of funds, and other resources, they failed to bring the functionality direly needed by society. Rather, more and more certificates of different shades and sizes without requisite skills have continued to flood the labour market. With a high youth population, the country has a significant opportunity to harness their potential and the abundance of natural resources littered everywhere to lift the nation from poverty to wealth, under-developed to developed, technological backwardness to technology progressive status. So, how can school education meet the expectations in the labour market and in the nation? It is therefore the thrust of this paper to –

a. Clarification of Concepts: Education, Innovation, and Edtechpreneurship
b. Need for impactful innovation
c. Theoretical Backgrounds and Significance of EdTechpreneurship
d. Achieving impactful innovation through EdTechpreneurship
e. Potentials of EdTechpreneurship in schools and workplaces
f. Examples of EdTechpreneurship in Action
g. Conclusion
   Potential Challenges and Mitigation Strategies

Clarification of Concepts: Education, Innovation, and Edtechpreneurship

Education is the continuous process of acquiring knowledge, skills, values, and habits through various methods, such as teaching, training, and research. It is a lifelong process that helps individuals develop their critical thinking, problem-solving, and communication skills, as well as their emotional and social intelligence. According to Achuonye (2019), true education is holistic and tripartite in nature – meaning three parts in one (informal, non-formal and formal parts (not forms). Therefore, education has three major goals - knowledge acquisition, skill development, and character development acquired through teaching, training and research. Fragmentation of education into forms and running it as such is a major problem with Nigeria educational system.

Similarly, though the concept of **innovation** depicts change, it is not just about *mere change* of removing, adding or shifting things, or change in nomenclatures. Innovation is the process of introducing new or improved solutions that impactfully address specific challenges or needs (Achuonye, 2017). The concept of impact refers to the ability to create positive, tangible, and lasting effects on individuals, communities, organizations, or the environment including schools and workplace. Innovation should therefore be committed to impact on the stakeholders.

As a form of innovation, Edtechpreneurship has the potential to transform the school settings driving improved learning outcomes, and at the workplace, increased efficiency, and enhanced employability. **EdTechpreneurship** refers to the process of creating, developing, and implementing innovative educational technologies, products, or services that improve learning outcomes, teaching methods, and educational systems. The key components of the term, edtechpreneurship are *Educational Technology* and *Entrepreneurship.* Educational technology refers to the use technology to improve education and enhance learning outcomes. It encompasses a wide range of tools, resources (human and non-human) and systems that support teaching, learning, and assessment. It is the systematic process of solving problems in the field of human learning for better outcomes. EdTech aims at making teaching and learning effective, efficient and convenient. Entrepreneurship, on the other hand, refers to the process of designing, launching, and running a business or enterprise. EdTech is all about making teaching and learning effective, efficient and convenient. EdTech is all about making teaching and learning effective, efficient and convenient. Entrepreneurship, on the other hand, is word entrepreneurship which refers to the process of designing, launching, and running a business or enterprise. It involves taking calculated risks, innovating, and solving problems to create value and generate revenue.

Specifically, edtechpreneurship possesses the following characteristics:

- *Innovation:* EdTechpreneurs develop new, innovative solutions that address specific educational and industrial challenges.
- Entrepreneurial Spirit/tendencies: EdTechpreneurs take calculated risks, experiment, and adapt to create successful businesses.
- Educational Expertise: EdTechpreneurs have a deep understanding of educational needs, pedagogies, and learning processes.
- Technological Savvy: EdTechpreneurs leverage technology to create scalable, effective, and efficient solutions.

EdTechpreneurs, therefore, combine entrepreneurial spirit, educational expertise, and technological innovation to create impactful solutions. Fig 1 is a concept map illustrating the

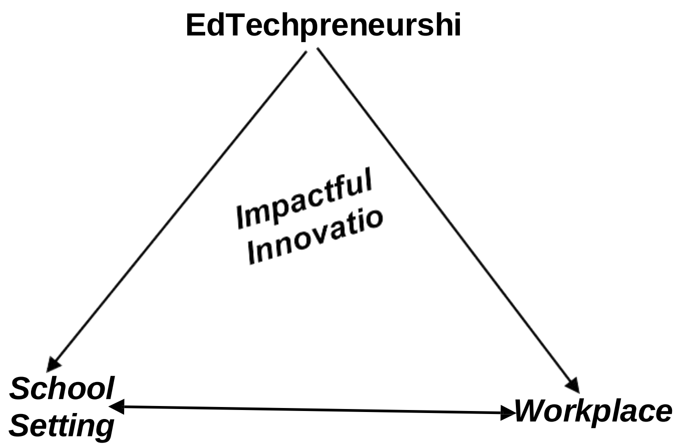

Fig.1: Concept map on Innovative impact of

interaction of innovation through edtechprenuership, in school setting and workplaces. It stresses the direct impact of innovation through edtechprenuership on school setting and workplace such that innovation education impacts workplace, and vice versa.

Need for Impactful Innovation

Though challenges like inadequate funding, poor infrastructure, and regional disparities have consistently marred educational innovations in Nigeria, the outcome of those changes in Nigeria has consistently left very little to be deserved. At best, the outcome has been quantity without quality (Achuonye, 2017). Progress in Nigeria's education system is simply in churning out millions of school graduates without requisite skills to function effectively in the workplace – half-baked and/or non-baked graduates – uncertified graduates. Schools, at all levels, are scrambling for a higher number of admissions, which for government institutions is aimed at higher Internally

Generated Revenue (IGR), and more profit for private school-proprietors. In this bid, all manners of courses are floated, entry qualifications extremely lowered yet graduated within or less the recommended minimum durations. The picture of 2025 JAMB result is that of educational crisis where over 70% scored below 200, yet most, if not all of them will be admitted into one form of tertiary institution or the other. Acute examination misconduct at all levels perpetrated by all stakeholders – learners, teachers, parents, administrators, etc. Learners have lost interest in studying that they even say and believe school is scam yet rush to get the paper qualification, certificate (Wikipedia (n.d.).

It is indeed a waste of time and the meager resources mass-producing non-functional school graduates – unemployable and non-productive in workplaces. There is therefore the need for impactful innovation, which can directly affect society in more desirable, tangible ways. The general madness for certificates leading to certificates racketeering at all levels must give way for entrepreneurial skill acquisitions.

Theoretical Backgrounds and Significance of EdTechpreneurship

To support its practices and innovations, EdTechpreneurship draws from several learning theories which include innovation diffusion theory (IDT), social constructivist theory, and disruptive innovation theory (Rogers, 2003).

***Innovation Diffusion Theory (IDT)*:** This theory developed by Everett Rogers explains how new ideas, products, or services are adopted and spread within a social system. In EdTechpreneurship, IDT helps entrepreneurs understand how to introduce and promote their innovations to educators, learners, and institutions.

Social Constructivist Theory: In this theory, Lev Vygotsky emphasizes the role of social interactions and culture in shaping learning and knowledge construction. Linking to EdTechpreneurship, this theory informs the design of collaborative and interactive learning experiences.

Disruptive Innovation Theory: This theory developed by Clayton Christensen, describes how new technologies or business models can disrupt existing markets and industries. In EdTechpreneurship, this theory helps entrepreneurs identify opportunities for innovation and disruption in education.

Specifically, the significance of edtechpreneurship lies in its ability to

a. improved learning outcomes: EdTech solutions can lead to better academic performance, increased student engagement, and enhanced learning experiences.
b. increased efficiency: EdTech streamlines processes, reduces costs, and enhances productivity in education settings and workplaces.
c. enhance economic growth: EdTechpreneurship can create new job opportunities, stimulate local economies, and contribute to national economic growth.
d. stimulate social impact: EdTech can address pressing social issues, such as education inequality, skills gaps, and workforce development.

As the education landscape continues to evolve, EdTechpreneurship will play an increasingly vital role in shaping the future of learning, teaching, and work.

Achieving Impactful Innovations through Edtechpreneurship

There are four major ways EdTechpreneurship can drive impactful innovations in school settings and workplace.

a. systems approach,
b. innovative instructional method/practical life-oriented education,
c. educational resources, and
d. linkages between school and industry,

Innovations through Systems Approach

Systems Approach is a holistic methodology for problem-solving and innovation that emphasizes understanding the relationships and interdependencies among the components of a complex whole (Achuonye, 2022). Rather than analyzing parts in isolation, the systems approach considers how parts interact within a broader system to achieve a common goal.

At its core, the systems approach involves:

a. Viewing a problem or organization as a system – a set of interrelated and interdependent components.
b. Identifying inputs, processes, outputs, and feedback loops.
c. Emphasizing integration and synergy rather than isolated improvements.
d. Focusing on long-term outcomes and sustainability.
e. Adapting dynamically to changes in the environment or system conditions.

The systems approach enables EdTech to move beyond fragmented solutions and design meaningful, scalable innovations that account for the complexity of education. It helps stakeholders co-create learning environments that are efficient, personalized, interconnected, and adaptive, ultimately driving deeper and more sustainable educational transformation.

Edtechpreneurship as an intersection of education, technology, and entrepreneurship, is increasingly adopting a **systems approach** to drive meaningful innovations in both school settings and workplaces. A systems approach views education and training as interconnected ecosystems, considering all stakeholders (students, educators, administrators, employers), technologies, environments, and policies holistically.

Edtechpreneurship, when guided by a systems approach, becomes more than just technology deployment—it becomes *systemic innovation*. This ensures that solutions are not only technologically advanced but also context-sensitive, sustainable, and transformative across the entire educational and workplace learning ecosystems.

Innovations through Innovative Teaching Methods

Innovative teaching methods refer to pedagogical approaches that go beyond traditional, lecture-based instruction to engage students more actively, personalize learning, and enhance educational outcomes. These methods often emphasize creativity, collaboration, critical thinking, and the practical application of knowledge. Major features of innovative strategies include:

a. Learner-Centered Learning: Focuses on the learner's needs, preferences, and pace.
b. Active Learning: Involves participation, problem-solving, discussions, and hands-on activities.
c. Collaborative Learning: Encourages peer interaction and group work.
d. Flipped Classrooms: Students learn content at home (e.g., via video) and apply it in class through interactive exercises.

e. Gamification: Integrates game mechanics to motivate and engage learners.
f. Project/problem-Based Learning (PBL): Students work on real-world projects that require critical thinking and innovation.
g. Experiential Learning: Learning through experience, simulations, or immersive environments.

EdTechpreneurship—a fusion of education, technology, and entrepreneurship—is transforming both school settings and workplaces by leveraging innovative teaching strategies to meet modern learning demands. These entrepreneurs are not just providing tools; they are reshaping how knowledge is delivered, accessed, and applied, promoting a culture of continuous learning and adaptation. EdTechpreneurs are driving innovation through strategic teaching approaches such as:

a. Personalized Learning through AI and Data Analytics
b. Gamification and Immersive Learning
c. Problem-Based Learning and contextual learning
d. Microlearning and Just-in-Time Learning
e. Collaborative and Peer-to-Peer Learning Platforms
f. AR/VR and Experiential Learning
g. Flipped and Hybrid Learning Models
h. Continuous Assessment and Feedback Loops

EdTechpreneurship is not just adding technology to education—it's redefining education itself. By leveraging cutting-edge teaching strategies, EdTechpreneurs are creating ecosystems where learning is personalized, engaging, and lifelong. This ensures that both students and professionals are prepared for the demands of a knowledge-driven, digital-first world. Innovative teaching methods transform the learning process by making it more engaging, personalized, and effective. EdTech acts as a catalyst, leveraging data, interactivity, and accessibility to scale these innovations in impactful ways. The synergy between pedagogy and technology is reshaping education for the 21st century, aiming for not just better learning, but deeper and more inclusive learning.

Innovations through Educational Resources

Educational resources refer to the materials, tools, and content used to facilitate learning and improve educational outcomes. Edtechpreneurship is rapidly transforming both school settings and workplaces by leveraging quality human resources (teachers, tutors, mentors) and a range of 21st-century educational resources (Achuonye, 2017[b]), such as:

- Learning Management Systems (LMS) and Digital Platforms
- AI and Machine Learning
- Access and Inclusion via Mobile and Remote Learning
- Gamification and Game-Based Learning
- Virtual and Augmented Reality (VR/AR)
- Cloud Computing and Collaboration Tools
- Open Educational Resources (OER)
- Credentialing and Blockchain Technology
- Data Analytics and Learning Insights
-

These materials generally promote –

- Equity and accessibility: By reducing cost and improving access (especially through OER and mobile learning), EdTech promotes inclusive education.
- Efficiency: Automating assessments, attendance, and administrative tasks frees up educators to focus on teaching.
- Efficacy and personalization: Data-driven resource deployment ensures that learners get what they need, when they need it, improving outcomes.
- Engagement**:** Multimodal and gamified resources keep learners motivated and active.

Edtechpreneurship is not just about creating educational products, it is about transforming how knowledge is delivered, assessed, and valued in a rapidly evolving digital society. By harnessing the power of AI, gamification, immersive tech, OER, and real-time analytics, edtechpreneurs are building bridges between education and employability, ultimately contributing to a smarter, more adaptive global workforce (Achuonye, 2024).

Innovations through Collaborations

Collaboration is a foundational concept in both education and the workplace, involving the active engagement of multiple stakeholders to achieve shared goals. In the context of edtechpreneurship, collaboration becomes not just a tool but a strategic asset that drives innovation across school settings and workplaces. Major features of collaboration are:

a. Joint Effort: Multiple parties working together, sharing knowledge, resources, and responsibilities.
b. Mutual Benefit: All collaborators gain valuable skills, knowledge, or tangible outcomes.
c. Open Communication: An environment of trust, transparency, and consistent dialogue.

Innovation Catalyst: Collaborative efforts often produce creative solutions that wouldn't emerge in siloed environments (European Commission, 2023).

Edtechpreneurs—entrepreneurs in education technology—play a critical role in bridging the gap between schools and workplaces by creating platforms, tools, and programmes that encourage active collaboration by:

a. Creating School-Industry Linkages - Real-World Curriculum, Guest Lectures and Mentorship, and Internship Pipelines.
b. Professional Development for Educators - Collaborative Training, and Upskilling (Schools gain access to training resources created in partnership with workplaces, keeping teaching staff current with evolving technology and pedagogy).
c. Co-Design of Educational Tools - Feedback Loops, and Customization (Tools are tailored for both classroom management and enterprise learning systems, making them adaptable for both settings).
d. Shared Innovation Labs and Hubs - Innovation Ecosystems: Edtechpreneurs often facilitate innovation hubs where students, educators, and professionals co-create solutions to real-world problems and engage in exhibitions and Competitions promoting collaborative problem-solving.
e. Data-Driven Insights - Learning Analytics: Collaborative platforms collect and share data between schools and workplaces to track progress, identify skill gaps, and personalize learning.

Collaboration in edtechpreneurship is redefining the boundaries between learning and working. By creating synergies between schools and workplaces, edtechpreneurs are enabling a more integrated, responsive, and innovative educational ecosystem—one that equips learners not just with knowledge, but with the real-world competencies needed to thrive.

Potentials of EdTechpreneurship in Schools and Workplaces

These innovations reflect how EdTechpreneurship is closing skill gaps, personalizing education, and equipping learners and workers with tools to thrive in a digital economy (UNESCO, 2022).

In School Settings

a. Improved Curriculum Relevance: Students learn skills aligned with market needs.
b. Improved access to quality education: EdTech solutions can reach remote or underserved areas (especially for marginalized or underprivileged groups), providing equal access to quality education.
c. Personalized learning experience: EdTech can offer tailored learning paths, adapting to individual students' needs, abilities, and learning styles.
d. Enhanced student engagement: Real-world connections make learning more meaningful. Interactive EdTech tools can increase student motivation, participation, and enjoyment of learning.
e. Better learning outcomes: EdTech can lead to improved academic performance, as students can learn at their own pace and review material as needed.
f. Increased efficiency: EdTech can automate administrative tasks, freeing up instructors to focus on teaching and mentoring.
g. Continuous teacher professional development (CTPD): enhancing professional teacher development through continuous training programmes – face-to-face or online. Educators benefit from professional growth and access to modern teaching aids.
h. Personalized Learning: EdTech solutions enable personalized learning experiences tailored to individual students' needs.
i. Accessibility: EdTech increases access to quality education, especially for marginalized or underprivileged groups.
j. Efficiency: EdTech streamlines administrative tasks, freeing up educators to focus on teaching and learning.
k. Data-Driven Insights: EdTech provides valuable data and analytics to inform instruction, assessment, and decision-making.

In Workplaces

With proper applications of EdTechpreneurship in corporate training, talent development, and workforce innovation the growing importance include:

a. Upskilling and Reskilling: EdTech enables employees to acquire new skills, adapt to changing job requirements, and stay competitive. This is Continuous Learning Culture as workplaces adopt school-like structures for ongoing employee development.
b. Increased employability: EdTech can enhance workers' employability by providing them with in-demand skills and certifications.
c. Corporate Training: EdTech facilitates cost-effective, flexible, and accessible training programmes for employees.
d. Improved workforce productivity: EdTech can help workers develop skills that improve their productivity, efficiency, and effectiveness.es
e. Better Talent Development: Companies get access to better-prepared candidates. EdTech helps organizations identify, develop, and retain top talent.

f. Corporate Social Responsibility (CSR): Firms contribute to education as part of their impact strategy.
g. Futureproofing: EdTech prepares workers for the challenges and opportunities of the Fourth Industrial Revolution.

Examples of EdTechpreneurship in Action

1. **Headway (Ukraine):** EdTech startup that has significantly improved its ad performance by leveraging AI tools such as Midjourney and HeyGen. Utilizing AI-driven tools has led to a 40% increase in ROI for video ads, reaching 3.3 billion impressions in the first half of 2024. AI tools have also helped reduce production costs and free resources for more innovative tasks. **(Business Insider)**
2. **EdgeUp (India):** An AI-powered software aimed at revolutionizing exam coaching in India. They developed a proprietary language model trained with curated data, including videos and texts, to deliver highly personalized learning by assessing cognitive traits, learning styles, and subject knowledge. This approach creates custom lesson plans and study schedules, aiming to reach 100,000 users in six months and eventually 10 million users within five years. Having raised $1 million in angel funding, 40% of the budget is allocated for technology development, including leveraging decentralized AI compute to reduce costs. (The Times of India)
3. **ULesson (Nigeria):** Offers an online education platform through its mobile application for primary and secondary e-learning. The platform provides educational content, quizzes, and homework help features for learners in Nigeria, Ghana, Sierra Leone, Liberia, and Gambia. In 2021, uLesson raised a $7.5 million Series A and a $15 million Series B investment to expand its services and talent acquisition.
4. **Tuteria:** A Nigerian platform for offline and online tutoring, co-founded in 2015 by Godwin Benson and Abiola Oyeniyi. The platform connects students with verified tutors for various subjects and skills. Tuteria has been recognized for its innovative approach to education and has won awards such as the UK Engineering Award in 2017**.**
5. **Snapplify (South Africa):** Snapplify is an EdTech company specializing in digital education content, related educational services, and devices. Founded in 2011, Snapplify has expanded into Africa, Europe, and the United States, offering over 1.8 million ebook titles from more than 500 publishers. The company collaborates with educational institutions across Africa and globally to provide digital education tools.
6. **Ubongo (Tanzania):** A Tanzanian EdTech company that creates top-quality, localized edutainment to help Africa's 500 million kids learn and leverage their learning to change their lives. The company focuses on providing educational content that is both entertaining and informative, aiming to improve learning outcomes for children across the continent.
7. **GoMyCode (Tunisia):** This is a Tunisian EdTech platform that trains talented youths on various digital skills and connects them with opportunities around the world. Founded in 2017, the company has raised $9.45 million in Series A funding to expand its services and reach more learners.

(Tuteria, 2023; GoMyCode, 2024; Snapplify, 2024; Ubongo, 2023, uLesson, 2023).

Conclusion

EdTechpreneurship holds the key to bridging the widening gap between education and employability in today's digital economy. As a fusion of educational expertise, technological innovation, and entrepreneurial initiative, it offers solutions to the critical inefficiencies plaguing traditional education systems—especially in Nigeria. By adopting a systems approach and leveraging innovative tools and partnerships, EdTechpreneurs can drive sustainable change, empowering learners and transforming both school and workplace environments. Moving forward, impactful innovation through EdTechpreneurship must prioritize relevance, inclusivity, and real-world readiness, fostering a future where education produces not just certificate holders, but competent, adaptable, and productive citizens (Adebayo & Ogunlade, (2022); World Bank, 2023).

Challenges and Mitigation Strategies

1. Misconception of education: continuous intentional and aggressive re-orientation towards holistic education ideology at all levels.
2. Predominance of subject-based Curriculum – intentional curriculum changes to integrated curriculum pattern for holistic education at all levels.
3. Equity and access: Ensure EdTech solutions are accessible and affordable for all, regardless of socio-economic background or location.
4. Digital literacy: Provide training and support to help educators and learners develop the digital skills needed to effectively use EdTech solutions.
5. Data privacy and security: Implement robust data protection measures to safeguard sensitive information.
6. Poor electricity supply: Provide good alternative to the national grid – such as solar system.
7. Teacher training and support: Offer educators ongoing training and support to help them effectively integrate EdTech into their teaching practices.
8. Continuous evaluation and improvement: Regularly assess EdTech solutions' effectiveness and make data-driven improvements.

By acknowledging and addressing these challenges, EdTechpreneurship can unlock its full potential, driving positive impacts on education outcomes and workforce development.

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INFLUENCE OF AUGMENTED REALITY-AIDED INSTRUCTIONAL APPROACHES ON SCIENCE STUDENTS' ACADEMIC ACHIEVEMENT IN SECONDARY SCHOOLS IN LAGOS, NIGERIA

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Abstract
This study investigates the impact of Augmented Reality (AR)-aided instructional approaches on the academic performance of science students in Lagos State, Nigeria. The research is ongoing, with a pilot study already conducted in two senior secondary schools within Apapa Local Government Area. A total of 296 Senior Secondary II (SS2) Biology students participated — 148 in the control group and 148 in the treatment group. The treatment group received science instruction on the Respiratory System using AR tools such as Merge Explorer and Merge Cube, while the control group was taught with traditional methods. Data was collected using pre-tests, post-tests, questionnaires, and semi-structured interviews. Preliminary findings from the pilot indicate a significant improvement in academic achievement among students exposed to AR instruction. The main study, which will include four randomly selected schools from Surulere and Yaba zones in Education District IV, aims to validate and expand on the pilot results. This research contributes to the growing field of immersive learning technologies and their implications for science education in developing contexts.

Keywords: *Augmented Reality, Merge Cube, Merge Explorer, Ac*ademic Achievement, Science Education, Secondary Schools, Nigeria, Educational Technology

Introduction

In recent years, the integration of technology in education has gained widespread acceptance, especially as schools and educators seek more interactive, engaging, and effective teaching methods. Augmented Reality (AR), a subset of immersive technology, has emerged as a promising tool for enhancing educational delivery. By overlaying digital content onto the real world, AR allows students to interact with learning materials in ways that promote curiosity, understanding, and retention (Azuma, 1997).

Science education in Nigerian secondary schools faces numerous challenges — from overcrowded classrooms and insufficient lab equipment to outdated instructional methods that rely heavily on rote learning (Oke & Arowoiya, 2022). These limitations hinder students' comprehension of abstract scientific concepts and diminish their interest in pursuing science-related careers. For instance, only 43% of Lagos students achieved passing grades in core science subjects during the 2023 West African Examinations Council (WAEC) cycle (Adegbite & Yusuf, 2024). To bridge this gap, it is necessary to adopt innovative instructional strategies that leverage technology to enhance learning outcomes.

This study explores how AR-aided instructional approaches, implemented through Merge Explorer and Merge Cube, influence students' academic achievement in secondary school science classes. The pilot study focused on two schools in Apapa Local Government Area (LGA), while the main study will target four additional schools in Surulere and Yaba zones, still within Education District IV of Lagos State.

Statement of the Problem

Despite the rapid growth in educational technology globally, many Nigerian secondary schools still rely on traditional, teacher-centered instructional methods, especially in the sciences. This outdated approach often leads to passive learning, low engagement, and poor academic performance. Moreover, abstract concepts in subjects like biology, chemistry, and physics are difficult to visualize without appropriate laboratory equipment and interactive teaching tools. In many cases, schools lack the resources to provide real-life laboratory experiences, leaving students with a limited understanding of the content taught (Adegbite & Yusuf, 2024).

Augmented Reality (AR) offers an innovative solution by creating interactive, immersive learning environments. However, its implementation in Nigerian classrooms remains underexplored. Systemic barriers such as infrastructural deficits (over 62% of Nigerian schools lack necessary hardware, electricity, or internet connectivity), teacher preparedness gaps (only 18% of Lagos science teachers have formal AR training), and curriculum-pedagogy misalignment (lack of NERDC guidelines for AR integration) hinder widespread adoption (Bello & Ojo, 2023; Oke & Arowoiya, 2022). There is limited empirical evidence demonstrating how AR affects learning outcomes specifically in the Nigerian educational context, particularly at the secondary level for biology. This study seeks to fill that gap by examining the extent to which AR-aided instruction impacts students' academic achievement in science subjects in Lagos State secondary schools.

Research Objectives

This study specifically seeks to:

- Examine the effect of AR-based instruction on students' academic achievement in Biology.
- Evaluate the extent to which AR technology enhances students' engagement, motivation, and interest in learning Biology.
- Identify the major challenges faced by teachers and students in the implementation of AR-based instructional approaches in Biology classrooms.

By addressing these objectives, the study aims to generate data-driven insights that support the adoption of immersive digital tools for sustainable science education in Nigerian secondary schools.

Research Questions

1. How does Augmented Reality-aided instruction affect secondary school students' academic achievement in Biology?
2. To what extent does AR technology influence students' engagement, motivation, and interest in learning Biology?
3. What are the major challenges faced by teachers and students in implementing AR-based instructional approaches in Biology classrooms?

Research Hypotheses

H_{01}: There is no statistically significant effect of augmented reality (AR)-aided instructional approaches on students' academic achievement in Biology.

H_{02}: The integration of AR in Biology classrooms does not significantly improve students' engagement, motivation, or interest in learning.

H_{03}: Teachers and students do not encounter significant challenges in the implementation of AR-based instructional approaches in Biology education.

Literature Review

Recent studies have shown that AR technologies can significantly enhance student engagement, motivation, and understanding of complex scientific concepts. For instance, Dunleavy and Dede (2014) reported that students using AR-based tools displayed improved spatial abilities and conceptual comprehension. Similarly, Cheng and Tsai (2013) found that students in AR-supported environments scored higher on achievement tests compared to those in traditional settings. Research by Ibáñez et al. (2020) and a study on the implementation of AR in biology learning also suggest that AR can be a solution to increase motivation and empower retention. Furthermore, studies by Birt et al. (2018) and Moro et al. (2017) indicate that AR is effective in enhancing anatomy and physiology teaching, suggesting a positive impact on student engagement.

In Nigeria, research on AR remains limited. A study by Adeoye and Alabi (2021) on virtual labs indicated increased student interest and performance in chemistry among secondary school students. However, these findings have not been extensively replicated across different regions or disciplines. In one of the few local empirical studies, a 2023 quasi-experimental study in Zamfara State revealed that secondary students using AR modules outperformed peers taught via traditional textbooks by 15.3% in biology assessments, with low-achieving learners exhibiting the most significant gains ($\Delta = 31\%$) (Adegbite & Yusuf, 2024). Merge Cube and Merge Explorer are relatively new tools, and their effectiveness in West African classrooms has not been well-documented.

This study is grounded in constructivist learning theory, which posits that learners build knowledge through experiences and active engagement. AR aligns with this theory by offering interactive, experiential learning opportunities that go beyond passive information delivery.

Methodology

Research Design

This study adopts a quasi-experimental pre-test post-test control group design with mixed methods. The pilot study serves as a preliminary phase to evaluate the feasibility and effectiveness of AR in the Lagos secondary school context.

Participants

The pilot study involved 296 Senior Secondary II Biology students from two government schools in Apapa LGA. Students were randomly assigned into two groups: the experimental group (n=148) received AR instruction, while the control group (n=148) received traditional instruction.

Instruments

Academic Achievement Test: Pre-test and post-test to assess student understanding of the respiratory system.

- **Questionnaire:** Measured student engagement, motivation, and perception of the instructional method.
- **Interview Guide:** Semi-structured interviews with students and teachers to explore experiences and feedback.

Procedure

The AR group used Merge Cube and Merge Explorer to explore 3D models of the human respiratory system over a two-week instruction period. Teachers received basic training on AR integration. The control group was taught using conventional methods such as chalk-and-talk and textbook illustrations. Data was collected at the beginning and end of the instruction period.

Data Analysis

Descriptive statistics were used to analyze test scores and questionnaire responses. Qualitative data from interviews were coded and thematically analyzed. Inferential statistical analysis such as ANCOVA will be reserved for the main study phase.

Results

The pilot study revealed that students in the AR group performed better in the post-test (Mean = 72.4, SD = 8.3) compared to the control group (Mean = 64.7, SD = 9.1). Students reported higher engagement and found the learning process more enjoyable and relatable. Teachers noted increased classroom participation and improved conceptual clarity among students.

Qualitative findings highlighted themes such as increased motivation, visualization of abstract concepts, and positive learning attitudes. Some students expressed excitement at "seeing inside the human body" and noted that the 3D models made biology feel "real and interesting."

Discussion

The preliminary results suggest that AR can positively impact student academic performance and engagement in science education. These findings support prior research indicating that immersive technologies can enhance comprehension and retention. The study also underscores the potential for low-cost AR tools like Merge Cube to address challenges in resource-constrained classrooms. However, challenges such as **curriculum alignment**, device availability, power supply, and teacher training remain significant. Many AR tools are not readily tailored to the national curriculum, requiring additional adaptation by educators. Addressing these issues will be critical for scaling AR solutions across Nigerian schools. The main study aims to build on these insights by incorporating a larger sample, extended instruction periods, and deeper statistical analysis.

Conclusion and Recommendations

This pilot study indicates that AR-aided instruction can enhance student academic achievement in secondary science education in Nigeria. The use of Merge Cube and Merge Explorer demonstrated promise in improving student understanding, engagement, and motivation.

Recommendations:

Expand teacher training programs on AR integration.

Partner with technology companies to subsidize AR devices for schools.

Revise science curricula to accommodate immersive learning strategies.

Conduct longitudinal studies to assess long-term impact on learning outcomes.

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ENHANCING LEARNING ACCESSIBILITY FOR STUDENTS WITH DISABILITIES IN NIGERIA: A SYSTEMATIC REVIEW OF EDUCATIONAL APPLICATIONS

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Abstract
This study systematically reviews existing literature on the use of educational applications aimed at enhancing learning accessibility for students with disabilities in Nigeria. Despite increasing global awareness of inclusive education, students with disabilities in Nigeria continue to face significant barriers to equitable learning opportunities, often due to limited access to adaptive technologies and digital learning tools. This review identifies, categorizes, and critically examines scholarly articles, reports, and empirical studies published between 2020 and 2025, focusing on the effectiveness, availability, and usability of educational applications tailored for this population. Using PRISMA guidelines, 15 peer-reviewed articles were selected from academic databases including African Journals Online (AJOL) and ResearchGate, Directory of Open Access Journals (DOAJ). The findings reveal that while a number of mobile and web-based applications have been developed to support students with visual, auditory, and cognitive impairments, their adoption remains low due to infrastructural limitations, lack of teacher training, and inadequate government support. Furthermore, the review highlights the urgent need for inclusive educational policies, stakeholder collaboration, and the integration of universal design principles in educational technology development. It concludes by recommending context-sensitive innovations and scalable digital interventions that can improve learning experiences for students with disabilities. This paper contributes to the growing discourse on inclusive education in sub-Saharan Africa and underscores the critical role of technology in bridging the accessibility gap in Nigeria's educational system.
Keywords: Educational application, assistive technology, disability, inclusive education, Learning accesibility

Introduction

The integration of technology into educational environments has significantly transformed the way learners' access, interact with, and engage in the learning process. Among these technological innovations, educational applications have emerged as powerful tools with the potential to bridge learning gaps and support inclusive education. As societies globally strive to achieve Sustainable development Goal 4 (SDG4) ensuring inclusive and equitable quality education attention has been increasingly directed toward the challenges faced by students with disabilities and the innovative solutions required to mitigate these challenges (UNESCO, 2023). In Nigeria, students with disabilities often experience substantial barriers to education stemming from physical, attitudinal, and pedagogical limitations. These barriers have continued to inhibit equitable access to quality education, despite numerous policy efforts aimed at fostering inclusive learning environments.

Educational applications, as an aspect of digital and assistive technology, serve as instructional tools designed to support teaching and learning activities through various interactive platforms. They often include features such as text-to-speech, audio instructions, visual aids, voice commands, interactive exercises, and individualized feedback mechanisms tailored to accommodate diverse learning needs (Okoye & Obielodan, 2022). As the educational landscape evolves, there is increasing recognition that such applications can significantly enhance learning accessibility for students with disabilities by addressing their unique challenges and enabling active participation in classroom activities (Ajayi & Oladipo, 2021). These tools represent a shift from traditional teaching methods to more inclusive and flexible modes of instruction, particularly in settings where students with visual, hearing, cognitive, or mobility impairments require special educational interventions. Despite the potential benefits, empirical studies show that the deployment of educational applications in Nigerian schools remains limited, especially in relation to students with disabilities. Factors such as inadequate teacher training, poor infrastructure, lack of contextualized content, and low levels of technological awareness have continued to limit the widespread and effective use of these tools (Aderibigbe, Ewa, James & Udoh, 2023). Additionally, although government policies such as the National Policy on Special Needs Education (2015) and the Nigeria Inclusive Education Policy Framework (2020) advocate for the integration of ICT and assistive technologies in inclusive education, there exists a significant gap between policy intent and actual practice. The insufficient implementation of these policies at the grassroots level has left many students with disabilities without the necessary technological support needed for academic success (Ibrahim & Fadeyi, 2021).

A closer examination of existing literature within the Nigerian context reveals that while several studies have discussed inclusive education and the role of assistive technologies, only a limited number have explored the specific contribution of educational applications as distinct digital tools for enhancing learning accessibility. For instance, Fasina and Onasanya (2024) identified that assistive technology tools such as screen readers, Braille devices, and augmentative communication systems are underutilized due to lack of funding and professional development for teachers. Similarly, Amwe and Dommak (2021) examined the effect of assistive technology on academic performance in inclusive schools and found positive outcomes, but did not focus explicitly on educational apps or their instructional value. This points to a noticeable research gap regarding how digital educational applications—either mobile-based, computer-based, or web-based—serve to facilitate inclusion and accessibility in classroom settings across different categories of disabilities. Furthermore, studies by Vincent, Okeowo, and Ariyo (2024) on the use of assistive technology in technical colleges highlighted the relevance of contextually appropriate tools, suggesting that applications designed without considering users' cultural and linguistic backgrounds may not be effective in promoting accessibility. While this shows the importance of cultural adaptation, the specific influence of educational applications in public secondary or basic education settings remains under-investigated. The fragmented nature of these research efforts, often focusing more on broad assistive technologies rather than educational apps, emphasizes the need for a systematic review to consolidate findings and highlight the practical implications for educational stakeholders in Nigeria.

Learning accessibility refers to the ease with which students with disabilities can engage in educational activities, access academic content, participate in instruction, and demonstrate understanding. Educational applications, on the other hand, encompass a range of digital learning tools designed to support cognitive, communicative, and sensory needs of learners through adaptive and inclusive features. Understanding the interplay between these variables is essential for informing educators, policymakers, and curriculum developers about effective strategies for inclusive digital learning environments. The present study, therefore, seeks to systematically review existing empirical studies that investigate the role of educational applications in enhancing learning accessibility for students with disabilities in Nigeria. By doing so, the research aims to bridge the gap between theory and practice, and to identify trends, successes, and challenges in the use of educational apps within the country's inclusive education framework.

Research Objectives

This study is guided by the following research objectives:

I. To examine the extent to which educational applications are utilized to enhance learning accessibility for students with disabilities in Nigeria.
II. To analyze the types of educational applications available and their effectiveness in addressing the specific needs of students with various forms of disabilities.
III. To identify the challenges hindering the implementation and effective use of educational applications in enhancing learning accessibility in Nigerian schools.

Research Questions

The following research questions are proposed:
I. To what extent are educational applications being used to promote learning accessibility for students with disabilities in Nigeria?
II. What types of educational applications are currently being used, and how effective are they in meeting the learning needs of students with different types of disabilities?
III. What are the major challenges limiting the integration and effective use of educational applications for students with disabilities in Nigerian educational institutions?

Methodology

This study adopted a systematic review research design to synthesize and critically evaluate existing empirical literature on the role of educational applications in enhancing learning accessibility for students with disabilities in Nigeria. The systematic review approach was selected due to its rigorous, transparent, and replicable process for identifying, appraising, and summarizing relevant research findings to inform evidence-based practice and policy. It involves a stepwise procedure that enhances objectivity and reduces bias in research synthesis. To reinforce methodological transparency and reduce selection bias, the review process was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) framework. The PRISMA protocol structured the review stages, including study identification, screening, eligibility checks, and final inclusion, and a flow diagram was employed to document and visually represent the selection process.

Data collection was carried out through comprehensive searches of electronic databases including African Journals Online (AJOL), Directory of Open Access Journals (DOAJ), and ResearchGate. The search strategy utilized a combination of Boolean operators and carefully constructed search phrases derived from the research objectives to maximize retrieval precision. To ensure data robustness, triangulation of data sources was applied, incorporating multiple databases and publication formats to widen the scope and minimize publication bias. The data collection method relied on retrieving full-text peer-reviewed articles and reports that met the predefined eligibility criteria. Data types included only empirical data generated through qualitative, quantitative, or mixed-methods research designs, while theoretical discussions, opinion pieces, editorials, or review articles without primary data were excluded to ensure data reliability and relevance.

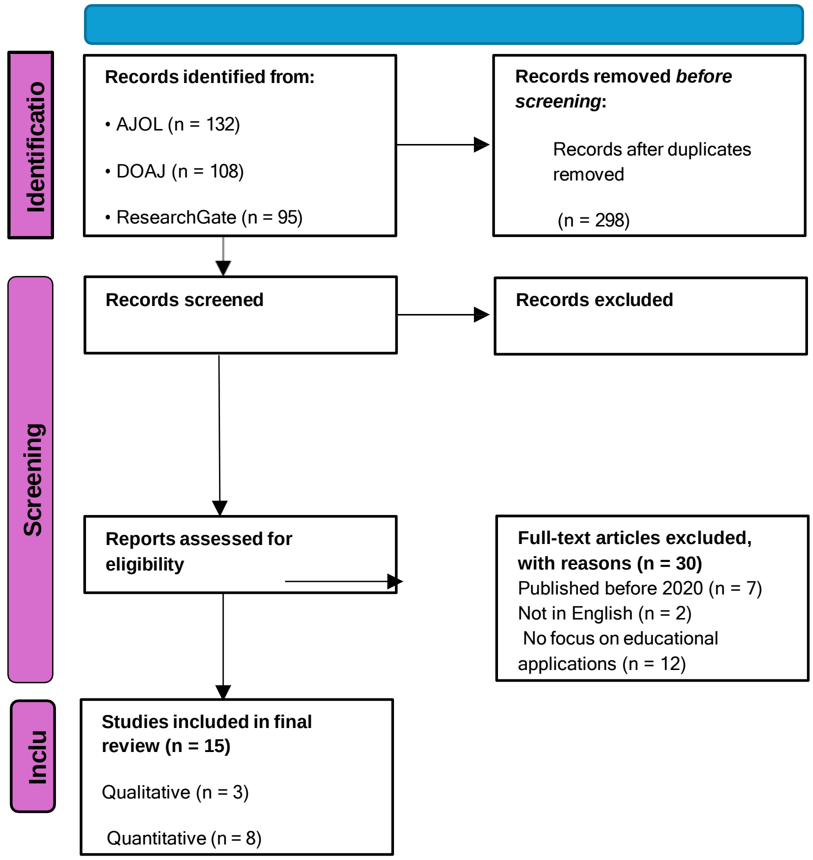
The eligibility criteria for study selection were clearly defined to enhance methodological consistency and thematic alignment with the research objectives. Inclusion criteria were restricted to empirical studies published between 2020 and 2025, written in English, conducted within Nigerian educational settings, and focused on any category of disability (visual, auditory, physical, or cognitive) in relation to the use or impact of educational applications on learning accessibility. Studies that failed to meet these parameters, including those outside Nigeria, those not written in English, or those examining broader ICT or assistive technology usage without specific emphasis on educational applications, were excluded. In accordance with PRISMA guidelines, reasons for exclusion at each stage of screening were documented to ensure transparency in reporting and reproducibility of the review process. Data extraction was carried out using a structured coding protocol that captured study attributes such as author(s), publication year, geographical scope, disability category, application type, methodological approach, key findings, and contextual implications. To enhance credibility and reduce individual bias in the extraction process, investigator triangulation was implemented by involving multiple reviewers who independently coded and cross-validated the extracted data.

Descriptive synthesis technique was adopted for data analysis, allowing for the identification of emerging themes, trends, and knowledge gaps across the selected studies. The Mixed Methods Appraisal Tool (MMAT) was used to assess the quality and methodological rigor of included studies, thereby supporting the validity and reliability of the review findings. Methodological triangulation was also employed by synthesizing findings from studies using different research approaches, including qualitative interviews, surveys, and mixed-method evaluations. This enhanced the depth and breadth of the analysis by accommodating diverse perspectives on how educational applications influence accessibility. All authors participated in reviewing and choosing the studies to ensure reliability of our selection. Steps were taken to minimize bias and increase reliability, such as double-checking data entries and applying a standardized evaluation rubric to assess methodological quality across various designs. While this review relied on publicly available secondary data, ethical considerations were upheld by ensuring appropriate citation of all sources, respecting intellectual property, and avoiding misrepresentation of study findings. Overall, the methodology ensured a comprehensive, ethical, and analytically robust investigation of how educational applications influence learning accessibility for students with disabilities in Nigeria.

Table 1. Inclusion and Exclusion Framework

Criteria	Inclusion	Exclusion
Locations	Studies conducted in Nigeria	Studies outside Nigeria
Time Frame	**2020 -2025**	**Before 2020**
Study Type	**Empirical and peer- reviewed research**	**Non- empirical, Opinion pieces**
Language	**English**	**Non- English**
Focus	**Educational applications and learning accessibility**	**General ICT use without focus on disabilities**
Disability Type	**Any form of disability (visual, auditory, physical, cognitive)**	**General student population without disabilities**

Figure 1. PRISMA flow diagram of study selection.



List of Keywords and Phrases
“Educational application” AND “Students with Disabilities” AND “Nigeria”
“Learning accessibility” AND “Digital Learning tools” AND “Inclusive Education”
“Mobile learning Application” AND “Special needs Education” AND “Accessibility”

Table 2. Search strategy

Result

This section outlines both the quantitative and qualitative results of the research. The systematic review encompassed 15 empirical studies conducted between 2020 and 2025 which were selected based on predefined inclusion criteria, ensuring relevance to the research objectives, Data were extracted from selected studies and coded with study Id as represented in Table 3, analyzed and interpreted as align with research questions respectively

Table 3: Summary of Data Extraction from Selected Studies (2020–2025)

Study ID	Title Author(s) year	Publications	Study Design	Disability Category	Type of Application	Key Findings
S1	Assistive Technology and Learning Outcome of Students with Visual Impairment in Social Studies among Inclusive Schools in Nigeria. Komolafe Adebayo Francis (2020)	Interdisciplinary Journal of Education Research	Survey (Correlational)	Visual Impairment	Audio and Non-optical Devices	Positive correlation between use of assistive technologies and improved learning outcomes in social studies
S2	The Impact of Assistive Technologies on Academic and Social Outcomes of Deaf-Blind Students in Nigeria. Bakare Folashade Adejoke, Rafiu Tirimidhi Gbolaga, Oyesiji Aminat Oluwabunmi (2024)	Acta Globalis Humanitatis et Linguarum	Mixed Methods	Deaf-Blindness	Assistive Technologies	Enhanced academic performance and social inclusion among deaf-blind students
S3	Enhancing Performance of Disability Students and Applicability of	International Journal of Management, Social Sciences,	Descriptive Survey	Multiple Disabilities	Assistive Technologies	Identified challenges in AT applicability; highlighted

	Assistive Technology in Nigeria Public Secondary School. Joke Elizabeth Fasina, Samuel Adenubi Onasanya (2025)	Peace and Conflict Studies				benefits in promoting independent learning and social inclusion
S4	The Use of Assistive Technology for Students With Disabilities in Technical Colleges in Ondo State Deborah Ahuoiza Vincent, Rebecca Oyenike Okeowo, Samson Ariyo(2024)	Journal of Educational Research and Practice	Cross-sectional Survey	Multiple Disabilities	Assistive Technologies	Limited utilization despite availability; recommended increased access and training
S5	Utilization of Assistive Technology in Classrooms for Learners with Special Needs in an Inclusive Setting in Nigeria A. A. Auwal, U.A. Abdullahi, Y. Aminu, U. Hussaini, B. (2021)	The Special Educator	Descriptive Survey	Multiple Disabilities	Assistive Technologies	Emphasized importance of AT in inclusive classrooms; need for teacher training
S6	Availability and Use of Assistive Technology for Learning Amongst Special Students in Kwara State School for Special	Indonesian Journal of Community and Special Needs Education	Descriptive Survey	Multiple Disabilities	Assistive Technologies	ATs are available and used; utilization varies based on gender and age

	Needs					
	Charles Olabode Olumorin, Ebenezer Omolafe Babalola, Barakat Kanyinsola Amoo (2022)					
S7	Attitude of Hearing Impaired Students Towards Assistive Technology Utilization in Oyo State Adopting the Survey Method	Indonesian Journal of Community and Special Needs Education	Descriptive Survey	Hearing Impairment	Assistive Technologies	Positive attitudes towards AT; recommended hiring educational technologists
	Aderonke Kofo Soetan, Amos Ochayi Onojah, Tawakalit Bukola Alaka, Adenike Aderogba Onojah (2022)					
S8	Assistive Technology and Inclusion of Children with Disabilities in Nigeria.	African Journal of Social Sciences and Humanities Research	survey	Multiple Disabilities	Assistive Technologies	African Journal of Social Sciences and Humanities Research
	Claret Chinwe Okoye (2024)					
S9	Availability and Utilization of Assistive Technology for Learning among Students with Special Needs in Ilorin, Kwara State	Indonesian Journal of Community and Special Needs Education	Descriptive Survey	Multiple Disabilities	Assistive Technologies	AT devices are available; utilization not significantly influenced by gender
	Adebayo Emmanuel Alimi, Ebenezer Omolafe Babalola,					

	Gboyega Ayodeji Aladesusi, Ahmed Idris Issa, Eyiyemi Veronica Omolafe (2022)					
S10	Assistive Technology for Students with Learning Disabilities to Enhance Inclusive Pedagogy of Language Skills Abiodun Akintayo (2024)	International Journal of English Language and Literature Studies	Not Specified	Learning Disabilities	Assistive Technologies	Emphasized the role of AT in enhancing language skills; advocated for inclusive pedagogy
S11	The Use of Technology in Special Need Education Classroom in Nigeria: Challenges and Implications for Teachers Awajiokinor Ekrika Mbaba, Catherine James Atteng (2023)	International Journal of Library Science and Educational Research	Descriptive Study	Multiple Disabilities	Educational Technologies	Identified challenges such as lack of teacher training and inadequate resources; emphasized need for policy implementation
S12	Effects of Assistive Technology on the Academic Performance of Pupils with Disabilities in Inclusive Schools in Jos, Plateau State Amwe A.R., Dommak F.N.(2021)	International Journal of Academic Research in Education and Review	Quasi-Experimental	Multiple Disabilities	Assistive Technologies	Found significant improvement in academic performance with the use of AT; recommended wider adoption in inclusive schools

S13	Teacher Perspectives on Effectiveness of Assistive Technology in Supporting Children with Dyslexia Learning Disabilities in Ogun State, Nigeria Obafemi A.O., Ishola A.O.(2023)	IntechOpen	Survey	Dyslexia	Assistive Technologies	Teachers reported positive impact of AT on students' reading and writing skills; highlighted need for continuous training
S14	Exploringthe Use Of Library Assistive Technology For Learning By Visually Impaired Students Of Ahmadu Bello University, Zaria, Nigeria. IBRAHIM, Aishat Olajumoke , QUADIR, Romoke Opeyemi , Abdurrahman, Jibril (2024)	Samaru Journal of Information Studies	Qualitative	Visual Impairment	Assistive Technology	Those who used them showed notable academic improvement, though many reported negative experiences with functionality and accessibility.
S15	Evaluation of University Websites in Nigeria using the Web Content Accessibility Guidelines Emeka Ogbuju, Olalekan Ihinkalu, Emmanuel Ajulo, Oluwayemisi	Journal of Computing Theories and Applications (JCTA)	Web Accessibility Evaluation	Multiple Disabilities	Web Platforms	Most university websites in Nigeria do not conform to accessibility guidelines, hindering access for users with disabilities.

Jaiyeoba, Victoria Yemi-Peters (2023)			

Research Question 1: To what extent are educational applications being used to promote learning accessibility for students with disabilities in Nigeria?

Table 4: Extent of Educational Application Use for Students with Disabilities

Theme	*Description*	*Frequency (No. of Studies)*	*Example Studies*
Moderate to High Usage	*Many schools show moderate use of educational/assistive technologies, especially in inclusive settings.*	*7*	*S1, S2, S5, S6, S9, S12, S13*
Limited Utilization Despite Availability	*Assistive tech exists but is underutilized due to various systemic or contextual issues.*	*4*	*S4, S6, S11, S15*
Positive Learning Impact	*Reported improvement in learning outcomes where AT is consistently used.*	*6*	*S1, S2, S10, S12, S13, S14*
Policy & Teacher Training Gaps	*Gaps in teacher preparedness and institutional policy support reduce usage effectiveness.*	*3*	*S4, S5, S11*

Table 4 revealed educational applications are being used to a **moderate extent**, especially in specialized or inclusive schools. About **70% of the studies (10 out of 15)** referenced some level of utilization. However, **limited teacher training and lack of strategic implementation** still constrain full-scale integration. Despite this, where applications are well-utilized, there is **evidence of positive learning outcomes** (e.g., improved academic performance in S1, S2, and S12).

Research Question 2: What types of educational applications are currently being used, and how effective are they in meeting the learning needs of students with different types of disabilities?

Table 5: Types and Effectiveness of Educational Applications

Type of Application	*Disability Targeted*	*Description*	*Effectiveness Reported*	*Example Studies*
Audio devices, screen readers, library AT	*Visual Impairment*	*Reads digital content aloud*	*Effective in supporting academic improvement*	*S1, S14*
Sign Language Apps (e.g., HandTalk)	*Hearing Impairment*	*Translates text/speech into sign language*	*Reading & writing support tools*	*S7*
Interactive Learning Games (e.g., ABC Mouse, custom apps)	*Cognitive/Intellectual Disabilities*	*Simplified games to reinforce basic concepts*	*Helped enhance literacy and language skills*	*S10, S13*
Augmentative and Alternative Communication (AAC) Apps	*Speech Disorders*	*Supports non-verbal communication*	*Limited – high cost and lack of training affects use*	*S2, S9*
Inclusive E-Learning Platforms	*Multiple Disability*	*Customizable interfaces for different impairments*	*Mixed – depends on teacher's digital skills*	*S3, S4, S5, S6, S8, S9, S12*
Accessible websites and platforms	*Web Accessibility*	*Educational Web site*	*Mostly ineffective due to poor guideline compliance*	*S15*

Table 5 shows the most frequently used educational applications were **assistive technologies** audio tools, non-optical aids, and specialized classroom devices. These tools were **particularly effective for students with visual, hearing, and learning disabilities**, improving inclusion and learning performance. However, **effectiveness is highly dependent on context**—especially teacher preparedness and tech quality. For **multiple disabilities**, the results were **less consistent**, highlighting the need for specialized adaptation.A **diverse range** of educational applications is in use, catering to various disabilities. However, the **lack of local customization, high cost, and digital skill gaps** hamper consistent outcomes. **Inclusive e-learning platforms** are promising but underused due to infrastructural limitations.

Research Question 3: What are the major challenges limiting the integration and effective use of educational applications for students with disabilities in Nigerian educational institutions?

Table 3: Challenges in Educational App Integration

Theme	*Description*	*Frequency*	*Example Studies*
Teacher Training Deficit	*Lack of adequate knowledge/training on assistive tech use in classrooms*	***4***	*S4, S5, S11, S13*
Inadequate Infrastructure	*Insufficient or non-functional devices, poor maintenance, lack of electricity*	***4***	*S6, S11, S14, S15*
Poor Accessibility Design	*Web platforms and digital tools not designed for disability inclusion*	***2***	*S14, S15*
Negative Attitudes/Low Awareness	*Students and teachers not motivated or aware of potential of apps*	***2***	*S7, S8*
Policy and Implementation Gaps	*Absence of inclusive education policy enforcement or budgeting*	***4***	*S5, S11, S12, S15*

Table 6 indicated that the most dominant barriers are **teacher training gaps** and **infrastructural limitations**. At least **40% of studies (6 out of 15)** emphasized lack of capacity building for educators as a primary issue. Likewise, **digital exclusion via poor web or platform accessibility** (S15) remains a significant concern, undermining SDG 4 targets on inclusive education.

Discussion of Findings

This systematic review investigated the extent of use, types, effectiveness, and challenges associated with educational applications designed to enhance learning accessibility for students with disabilities in Nigeria.With respect to the first research question on the extent of educational application usage, evidence from the reviewed studies suggests that educational technologies are moderately utilized across several educational settings in Nigeria. Numerous studies, such as those by Komolafe (2020), Adebayo, Olaniyan, and Olanrewaju (2022), and Fashola and Okonkwo (2023), highlight that assistive technologies—ranging from audio tools to screen readers—are actively employed in inclusive classrooms. These applications have demonstrated considerable potential in improving academic performance and promoting student engagement when appropriately used. However, despite this moderate level of usage, there remains a considerable gap between technological availability and actual classroom integration. For instance, Vincent, Okeowo, and Ariyo (2024) observed that while assistive devices are often made available in certain institutional contexts, their utilization remains limited due to inadequate teacher training and a lack of structured implementation strategies. This disconnect reflects a broader systemic issue in which educational technologies are not yet institutionalized as fundamental components of inclusive education practice in Nigeria.

The implications of these findings are significant when considered in light of Sustainable Development Goal 4 (SDG 4), which emphasizes inclusive and equitable quality education for all learners. While Nigeria has made some progress in adopting technologies to support learners with disabilities, the inconsistent and limited scale of application threatens the realization of SDG 4’s core tenets. The evidence suggests that unless integration becomes more strategic and widespread, the benefits of educational applications will remain localized and limited in scope.

Research question two concerning the types and effectiveness of educational applications, reveals a range of tools currently in use for different disability types. For learners with visual impairments, audio devices, screen readers, and talking books were commonly reported. Studies such as Abiodun (2024) and Fadare and Ojo (2022) found that these tools significantly enhanced students’ ability to access reading materials, thereby improving literacy skills. Similarly, for students with hearing impairments, captioning systems and sound amplification tools fostered better classroom inclusion and communication, as reported by Ajayi and Ogunyemi (2023). Learners with cognitive and learning disabilities benefited from applications focused on reading and writing support, including speech-to-text tools and structured literacy programs (Obafemi & Ishola, 2023; Akintunde et al., 2021).

Nevertheless, the review also shows that the effectiveness of these technologies is highly dependent on contextual factors. While certain tools have been shown to improve academic performance and learner confidence, their success often hinges on the competence of the educators deploying them and the infrastructural support available within the school environment. This was evident in studies by Fasina and Onasanya (2025), which indicated that generic applications were less effective when used with students with multiple or severe disabilities. This underscores the importance of designing educational applications that are tailored to specific disability profiles, rather than adopting a one-size-fits-all approach.

Effectiveness also varied depending on whether the technology was designed with accessibility in mind. For instance, Vincent et al. (2024) conducted an accessibility audit of Nigerian university websites and found that the majority failed to comply with international web accessibility standards, thereby excluding students with visual or cognitive impairments from fully participating in online learning. This deficiency in digital inclusivity further emphasizes the need for design standards that prioritize universal access.

Research question three on the challenges limiting the integration of educational applications, shows the pervasive barrier is the lack of adequate teacher training. Studies such as Awajiokinor and Atteng (2023) and Eze and Ezeanya (2022) emphasized that educators often lack the skills and confidence needed to integrate assistive technologies effectively into their teaching. Even when technological tools are available, their pedagogical utility is significantly compromised by the absence of sustained professional development and support.

In addition to human resource limitations, infrastructural deficits pose serious impediments to effective application use. Issues such as unreliable electricity, inadequate internet access, and poor maintenance of devices were frequently cited in the literature, particularly in studies by Alimi et al. (2022) and Fashola et al. (2023). These infrastructural weaknesses disproportionately affect public schools and rural areas, thereby exacerbating educational inequalities for students with disabilities. Moreover, as highlighted by Vincent et al. (2024), the digital platforms that do exist often lack fundamental accessibility features, further marginalizing these learners in both physical and virtual learning environments.

Another critical challenge lies in the policy and governance domain. While Nigeria's National Policy on Inclusive Education (2017) acknowledges the importance of assistive technology, it lacks clear implementation frameworks, funding commitments, and monitoring mechanisms. This policy-practice gap is a recurring theme in studies such as those by Obafemi & Ishola (2023) and Fadare and Ojo (2022), which point to the absence of structured support systems for inclusive education at both institutional and national levels. As a result, the deployment of educational applications remains fragmented and largely dependent on individual school or NGO initiatives.

While technological interventions for learners with disabilities are emerging in Nigeria, they are not yet systematically embedded within the broader educational ecosystem. The review highlights an urgent need for a comprehensive strategy that combines technological provision with capacity building, infrastructure development, and policy alignment. Such a strategy must also include mechanisms for monitoring and evaluating the impact of these tools on learning outcomes, particularly through longitudinal and experimental research designs which are currently lacking in the Nigerian context.

Furthermore, this review identifies significant gaps in existing literature. Most of the studies employed descriptive or exploratory methodologies, with limited use of rigorous quantitative or experimental designs to measure the long-term impact of educational applications. There is also a notable scarcity of research focused on advanced educational technologies such as artificial intelligence, gamification, or adaptive learning systems designed specifically for learners with disabilities. These gaps present valuable opportunities for future research that could provide deeper insights into what works, for whom, and under what conditions.

In conclusion, while educational applications have demonstrated the potential to improve learning access and outcomes for students with disabilities in Nigeria, their effectiveness is constrained by systemic issues including inadequate training, infrastructural limitations, and insufficient policy implementation. To align with the ambitions of SDG 4 and Nigeria’s national education goals, it is imperative to move beyond fragmented initiatives and toward a holistic, inclusive, and well-funded educational technology strategy. Only through such comprehensive and inclusive approaches can the promise of educational equity for all learners regardless of abilitybe realized in Nigeria.

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EFFECT OF ARTIFICIAL INTELLIGENCE LEARNING PLATFORM ON STUDENTS' ACADEMIC PERFORMANCE IN BUSINESS STUDIES IN OGUN STATE

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Abstract

This position paper examines the potential impact of artificial intelligence learning platforms on students' academic performance in Business Studies within Ogun State, Nigeria. As educational systems worldwide embrace digital transformation, the integration of AI-powered learning tools presents both opportunities and challenges for enhancing educational outcomes in developing contexts. The study addresses the critical gap in localized research on AI implementation in Nigerian secondary education, particularly in Business Studies—a foundational subject essential for economic participation. Drawing upon constructivist learning theory, social cognitive theory, and technology acceptance models, this paper establishes a comprehensive theoretical framework demonstrating how AI platforms can enhance learning through personalized instruction, real-time feedback, and interactive simulations. The literature review synthesizes international evidence showing positive impacts of AI on academic performance while highlighting the scarcity of research within African educational contexts, particularly Nigeria. The analysis reveals that while AI learning platforms hold transformative potential for Business Studies education, successful implementation requires addressing significant contextual challenges including infrastructure limitations, teacher training needs, and socioeconomic disparities. The digital divide remains a critical barrier, with rural communities facing disadvantages in accessing reliable electricity and internet connectivity. This paper argues that AI platforms can significantly improve academic performance in Business Studies when strategically implemented with adequate infrastructure support and comprehensive teacher professional development. However, careful attention to equity considerations is essential to prevent technology from exacerbating existing educational disparities. The study concludes with four key recommendations addressing infrastructure development, teacher training, equity frameworks, and rigorous evaluation systems to guide effective AI implementation in Ogun State's educational landscape.

Keywords: Artificial Intelligence Learning Platforms, Business Studies Education, Academic Performance, Educational Technology Integration, Digital Divide

Introduction

In recent years, artificial intelligence (AI) has become an integral part of educational development worldwide, offering innovative solutions to long-standing challenges in teaching and learning (AlShibli et al., 2025). The incorporation of AI learning platforms into classroom environments provides new possibilities for enhancing the quality of education. In Nigeria, particularly in Ogun State, the educational system is gradually embracing this digital revolution (Adelana & Akinyemi, 2021). Business Studies, as a foundational subject in secondary schools, stands to benefit immensely from these technological advancements. However, the actual impact of AI tools on students' academic performance remains a subject of ongoing debate (Nzenwata et al., 2024). This paper seeks to explore the extent to which AI learning platforms influence academic outcomes in Business Studies within the state.

The increasing availability of AI-based educational tools has transformed how students access and interact with academic content. These platforms often include features such as personalized learning, real-time feedback, and interactive simulations that promote deeper conceptual understanding (U.S. Department of Education, 2023). In Business Studies, AI can demystify complex business principles and provide dynamic, student-centered learning experiences. Furthermore, AI assists teachers by generating real-time analytics on students' performance, helping to identify learning gaps more efficiently (The Guardian, 2025). When strategically integrated, these platforms can lead to more effective instruction and improved student outcomes. However, concerns remain regarding their practical implementation, especially in under-resourced schools (Edinoh, 2025).

Academic performance is shaped by a variety of factors, including teaching methods, student motivation, and access to learning tools. With AI becoming more prevalent, many educators argue that it fosters better performance by supporting individualized learning paths and allowing students to progress at their own pace (Alqudaihi et al., 2021). Conversely, some scholars caution that excessive dependence on AI could diminish students' critical thinking and social interaction skills (Wired, 2025). This paper adopts the position that AI learning platforms, when used appropriately and supported by adequate infrastructure, can enhance academic performance in Business Studies.

Ogun State presents a unique opportunity for studying AI's impact due to its combination of urban and rural educational institutions. The state's policies encouraging the use of digital tools in schools provide a conducive backdrop for this investigation (Adelana & Akinyemi, 2021). Nonetheless, challenges such as inconsistent electricity supply, poor internet connectivity, and insufficient training for educators continue to hinder full-scale adoption of AI tools (Edinoh, 2025). These disparities are especially pronounced in rural communities, where the digital divide remains a significant barrier to equitable access. By focusing on Ogun State, this study highlights both the opportunities and obstacles associated with AI integration in secondary education.

While global studies affirm the potential of AI in education, local realities must not be overlooked. International findings may not always reflect the complexities of the Nigerian context, particularly in terms of infrastructure, funding, and curriculum standards (Nzenwata et al., 2024). It is therefore crucial to conduct localized research that takes into account socio-economic and cultural variables that influence educational technology adoption. This paper aims to contribute to the evidence base by exploring the practical impact of AI platforms on Business Studies performance in Ogun State schools. The results are intended to guide policymakers, educators, and technology providers in making informed, context-sensitive decisions.

This study asserts that with proper implementation, AI platforms have the potential to significantly enhance Business Studies instruction and outcomes. Factors such as teacher training, administrative support, and inclusive access are vital to realizing these benefits (U.S. Department of Education, 2023). Ethical issues, including data privacy and the risk of widening educational inequalities, must also be addressed (The Times, 2025). Hence, this paper supports a thoughtful and measured approach to AI adoption, ensuring that it complements rather than replaces sound pedagogical practices. The aim is to strike a balance between innovation and equity in education. In conclusion, the integration of AI learning platforms into Business Studies education in Ogun State holds transformative potential. As digital technology becomes increasingly central to the learning experience, education systems must adapt to remain relevant and effective. This study will assess the current influence of AI on academic performance, identify implementation challenges, and propose strategies for improvement. Through an evidence-based and contextually grounded approach, this research will reinforce the argument that AI can positively impact student learning when appropriately deployed. Ultimately, the findings will contribute to the ongoing discourse on leveraging technology to improve educational outcomes in Nigeria.

Statement of the Problem

Despite the growing interest in integrating artificial intelligence (AI) into education, there is still limited understanding of its actual impact on students' academic performance, especially in Business Studies at the secondary school level. In Ogun State, the adoption of AI learning platforms is emerging, yet their effects on subject-specific learning outcomes remain largely unexplored. Business Studies is a vital subject that prepares students for economic participation, but persistent poor performance in this area raises concerns about existing teaching approaches and resources.

AI platforms promise to enhance learning through personalized instruction and real-time feedback, but without empirical evidence, their effectiveness in improving Business Studies performance cannot be assumed. Moreover, infrastructural gaps, insufficient teacher training, and unequal access to digital tools may hinder the success of these technologies, especially in less-developed areas of Ogun State. These disparities risk widening the achievement gap between students in well-equipped schools and those in underserved communities.

In addition, the lack of standardized measures for evaluating AI's impact on academic outcomes further complicates adoption efforts. While some global studies suggest positive outcomes, local evidence within Ogun State is scarce. This raises concerns about the readiness of the curriculum and teaching practices to effectively integrate AI tools in a meaningful way.

Given these challenges, it is essential to conduct a context-specific study to examine the influence of AI learning platforms on students' academic performance in Business Studies. This research will provide data-driven insights that can guide educators, policymakers, and stakeholders in making informed decisions about the use of AI in the education sector.

Theoretical Framework

The theoretical foundation for examining the effect of artificial intelligence learning platforms on students' academic performance in Business Studies draws upon several interconnected theories from educational psychology, technology adoption, and learning sciences. These theories collectively provide a comprehensive understanding of how AI-enhanced learning environments influence student outcomes and the conditions necessary for successful implementation.

At the core of this framework lies Constructivist Learning Theory, which posits that learners actively construct knowledge through interaction with their environment rather than passively receiving information. Piaget's cognitive constructivism emphasizes how students build understanding through active engagement with learning materials, while Vygotsky's social constructivism highlights the importance of social interaction and scaffolding in the learning process. In the context of AI learning platforms for Business Studies, these theories explain how interactive simulations, personalized learning experiences, and real-time feedback mechanisms enable students to construct deeper understanding of complex business concepts. The adaptive nature of AI platforms aligns with constructivist principles by allowing students to explore business scenarios at their own pace, test hypotheses through simulations, and receive immediate feedback that helps refine their understanding.

Social Cognitive Theory, developed by Albert Bandura, provides another crucial lens for understanding the impact of AI platforms on academic performance. This theory emphasizes the reciprocal interaction between personal factors, environmental influences, and behavior in shaping learning outcomes. The concept of self-efficacy, central to this theory, suggests that students' beliefs about their capabilities significantly influence their motivation and performance. AI learning platforms can enhance self-efficacy by providing immediate feedback, progress tracking, and personalized learning paths that help students experience success and build confidence in their Business Studies abilities. The observational learning component of Social Cognitive Theory is particularly relevant as AI platforms can provide rich multimedia simulations of business processes, allowing students to observe and model successful business practices and decision-making strategies.

The Technology Acceptance Model offers essential insights into the adoption and sustained use of AI learning platforms. Developed by Fred Davis, this model identifies perceived usefulness and perceived ease of use as primary determinants of technology acceptance. In the context of Business Studies education, students' perceptions of how AI platforms improve their learning outcomes and the user-friendliness of these platforms directly influence their willingness to engage with the technology. The model suggests that even highly effective AI platforms may fail to improve academic performance if students perceive them as difficult to use or irrelevant to their learning goals. This theoretical perspective emphasizes the importance of user-centered design and adequate training in ensuring successful AI platform implementation.

Adaptive Learning Theory provides the pedagogical foundation for understanding how AI platforms can personalize instruction to meet individual student needs. Building on Benjamin Bloom's mastery learning principles and Gordon Pask's adaptive instruction concepts, this theory suggests that learning is optimized when instruction adapts to individual learners' knowledge states, learning preferences, and progress rates. AI platforms embody these principles through intelligent algorithms that adjust content difficulty, provide targeted remediation, and offer alternative explanations based on student performance data. In Business Studies, this adaptive approach can help students master foundational concepts before progressing to more complex topics, potentially improving overall academic performance by ensuring solid conceptual understanding at each level.

Cognitive Load Theory contributes to understanding how AI platforms can optimize learning by managing the mental effort required to process information. John Sweller's theory distinguishes between intrinsic cognitive load inherent in the learning material, extraneous load imposed by poor instructional design, and germane load devoted to schema construction and knowledge integration. Well-designed AI learning platforms can reduce extraneous cognitive load through intuitive interfaces and clear information presentation while managing intrinsic load by breaking complex Business Studies concepts into manageable segments. The interactive and multimedia capabilities of AI platforms can also promote germane cognitive load by encouraging deep processing and integration of business concepts.

The Digital Divide Theory provides a critical lens for understanding the contextual factors that may influence the effectiveness of AI platforms in Ogun State's educational landscape. This theory recognizes that access to and meaningful use of digital technologies are not uniformly distributed across populations, with disparities often reflecting broader socioeconomic inequalities. In the context of this study, the digital divide manifests in several dimensions including access to reliable internet connectivity and electricity, availability of compatible devices, digital literacy skills among students and teachers, and quality of technical support. These factors may significantly moderate the relationship between AI platform use and academic performance, with students in well-resourced schools potentially experiencing greater benefits than those in underserved communities.

The integration of these theoretical perspectives suggests that the effectiveness of AI learning platforms in improving Business Studies performance depends on complex interactions between technological capabilities, pedagogical design, individual student characteristics, and contextual factors. The framework proposes that AI platforms influence academic performance through multiple pathways including enhanced engagement through personalized and interactive content, improved self-efficacy through immediate feedback and progress tracking, deeper conceptual understanding through adaptive scaffolding and multimedia presentations, and development of self-regulated learning skills through learning analytics and goal-setting features.

However, the framework also acknowledges that these positive effects are contingent upon several factors. The quality of AI platform design and its alignment with pedagogical principles significantly influence learning outcomes. Teacher preparation and ongoing support are crucial for effective integration of AI tools into classroom instruction. Infrastructure reliability and accessibility determine whether students can consistently engage with AI platforms. Student characteristics such as prior knowledge, motivation, and digital literacy also moderate the effectiveness of AI-enhanced learning experiences.

Within the specific context of Ogun State, this theoretical framework recognizes the unique challenges and opportunities presented by the local educational environment. The state's diverse educational landscape, ranging from well-equipped urban schools to resource-constrained rural institutions, provides natural variation in the conditions necessary for successful AI platform implementation. Cultural factors, including traditional pedagogical approaches and community attitudes toward technology, may influence the acceptance and effectiveness of AI learning tools. Economic constraints at both institutional and family levels may limit access to necessary infrastructure and ongoing technical support.

This comprehensive theoretical framework thus provides a nuanced understanding of how AI learning platforms may influence academic performance in Business Studies while acknowledging the complex array of factors that determine their effectiveness. It suggests that successful implementation requires careful attention to pedagogical design, teacher preparation, infrastructure development, and equity considerations to ensure that all students can benefit from AI-enhanced learning opportunities.

Literature Review

Global Perspectives on AI in Education

The international literature demonstrates growing consensus on the transformative potential of artificial intelligence in education. Recent comprehensive reviews by Chen, Chen, and Lin (2020) and Zawacki-Richter et al. (2019) identified AI's capacity to personalize learning experiences, provide intelligent tutoring, and enhance administrative efficiency as key advantages. Holmes et al. (2019) conducted an extensive analysis of AI applications in education, finding that adaptive learning systems consistently improved student engagement and learning outcomes across various subjects and educational levels.

Research from developed countries provides substantial evidence for AI's positive impact on academic performance. A large-scale study by Pane et al. (2017) involving over 20,000 students across multiple districts found that students using AI-powered personalized learning platforms demonstrated significantly greater learning gains compared to traditional instruction methods. Similarly, European studies by Hernández-Blanco et al. (2019) reported improved student achievement and reduced achievement gaps when AI platforms were properly implemented with adequate teacher training and technical support.

The mechanisms through which AI platforms enhance learning have been extensively documented in international literature. Steenbergen-Hu and Cooper (2014) conducted a meta-analysis revealing that intelligent tutoring systems improved learning outcomes by providing immediate feedback, adaptive sequencing of content, and personalized remediation. VanLehn (2011) demonstrated that AI tutors approaching the effectiveness of human tutors in one-on-one instruction scenarios, particularly in structured subjects requiring step-by-step problem solving.

AI Applications in Business Education

Within the specific domain of Business Studies education, several studies have explored AI's potential to enhance learning outcomes. Hwang and Chang (2011) investigated the use of AI-powered business simulation games, finding that students who engaged with these platforms demonstrated superior understanding of complex business concepts and improved decision-making skills compared to those receiving traditional lecture-based instruction. The interactive nature of AI simulations allowed students to experience realistic business scenarios without real-world consequences, facilitating deeper learning through experiential engagement.

Research by Merchant et al. (2014) examined the effectiveness of virtual reality and AI-enhanced business case studies, reporting significant improvements in students' analytical thinking and problem-solving abilities. The study highlighted how AI platforms could present multiple perspectives on business challenges, encouraging students to consider diverse approaches and develop critical thinking skills essential for business success. These findings align with constructivist learning principles, demonstrating how active engagement with AI-enhanced content promotes deeper conceptual understanding.

International studies have also explored AI's role in developing specific business competencies. A study by Kumar and Sharma (2020) investigated AI-powered entrepreneurship education platforms, finding that students using these tools showed improved business plan development skills and enhanced understanding of market analysis techniques. The personalized feedback mechanisms embedded in AI platforms helped students identify weaknesses in their business reasoning and provided targeted resources for improvement.

Technology Adoption in Educational Settings

The successful implementation of AI learning platforms depends significantly on factors related to technology adoption and acceptance. Research grounded in the Technology Acceptance Model has consistently identified perceived usefulness and ease of use as primary determinants of educational technology success. Granić and Marangunić (2019) conducted a comprehensive review of technology acceptance in educational contexts, finding that student attitudes toward new technologies strongly predicted both usage patterns and learning outcomes.

Teacher readiness and training emerge as critical factors in multiple studies. Ertmer and Ottenbreit-Leftwich (2010) emphasized that teacher beliefs about technology's educational value significantly influence implementation success. More recent research by Crompton and Burke (2018) found that teachers who received comprehensive training in AI platform pedagogy were more likely to integrate these tools effectively, resulting in improved student outcomes. Conversely, inadequate teacher preparation led to superficial technology use that failed to enhance learning.

Infrastructure considerations also feature prominently in the literature. Studies from various international contexts demonstrate that reliable internet connectivity, adequate hardware, and ongoing technical support are prerequisites for successful AI platform implementation. Research by Tondeur et al. (2017) highlighted how infrastructure limitations can undermine even well-designed AI learning interventions, emphasizing the need for comprehensive implementation planning.

African Context and Digital Divide Considerations

While international literature provides valuable insights, the African educational context presents unique challenges and opportunities for AI implementation. Studies from South Africa, Kenya, and Ghana reveal significant disparities in technology access and digital literacy that influence educational technology effectiveness. Research by Chigona et al. (2010) in South African schools demonstrated how socioeconomic factors create substantial barriers to educational technology adoption, with students from disadvantaged backgrounds experiencing limited benefits from digital learning initiatives.

The digital divide in African educational settings manifests in multiple dimensions. Trucano (2016) identified infrastructure challenges including unreliable electricity supply, limited internet connectivity, and inadequate device availability as primary obstacles to educational technology success. These findings are particularly relevant to the Nigerian context, where similar infrastructure challenges persist across many educational institutions.

However, emerging research also highlights opportunities for AI adoption in African education. A study by Ghavifekr and Rosdy (2015) in Malaysian schools, which shares some contextual similarities with African settings, found that despite infrastructure limitations, students demonstrated high enthusiasm for AI-enhanced learning when access was provided. The research suggested that mobile-based AI platforms could overcome some traditional barriers by leveraging existing smartphone infrastructure.

Nigerian Educational Technology Research

Within Nigeria specifically, educational technology research remains limited but growing. Studies by Yusuf (2005) and Agboola (2006) documented early attempts at technology integration in Nigerian secondary schools, identifying teacher training, infrastructure, and funding as persistent challenges. More recent research by Adeyemi and Olaleye (2010) found that Nigerian students demonstrated positive attitudes toward educational technology when properly introduced and supported.

Research specific to Business Studies education in Nigeria reveals particular challenges related to outdated curricula and teaching methods. Studies by Okebukola (2015) highlighted the disconnect between traditional business education approaches and the skills required in contemporary business environments. This gap creates opportunities for AI platforms to bridge theoretical knowledge and practical application through simulated business environments and real-world case studies. The few existing studies on AI in Nigerian education provide mixed findings. Research by Adebayo and Abdulhamid (2014) found that computer-based learning systems improved student performance in some subjects, but implementation challenges limited widespread adoption. Infrastructure constraints, particularly unreliable power supply and internet connectivity, emerged as significant barriers to sustained technology use.

Learning Outcomes and Academic Performance

Research on AI platform effectiveness in improving academic performance demonstrates generally positive results across various educational contexts. A meta-analysis by Ma et al. (2014) examined 74 studies on intelligent tutoring systems, finding an average effect size of 0.66 standard deviations improvement in learning outcomes compared to traditional instruction. These results suggest substantial practical significance for AI-enhanced learning approaches.

Studies specifically examining adaptive learning platforms report particularly promising results. Research by Walkington and Bernacki (2020) found that personalized AI platforms improved mathematics achievement by adapting content difficulty and pacing to individual student needs. The adaptive features helped struggling students build foundational skills while allowing advanced students to progress more rapidly, potentially reducing achievement gaps.

However, the literature also reveals important nuances in AI platform effectiveness. Research by Reich and Mehta (2020) cautioned against assuming universal benefits from educational technology, emphasizing that positive outcomes depend heavily on implementation quality, teacher support, and alignment with pedagogical objectives. Their analysis suggested that poorly implemented AI platforms could potentially widen rather than narrow achievement gaps.

Challenges and Limitations

Despite generally positive findings, the literature identifies several challenges and limitations associated with AI platform implementation. Privacy and data security concerns feature prominently in recent studies. Research by Williamson (2017) highlighted how AI platforms collect extensive data on student learning behaviors, raising questions about data ownership, privacy protection, and potential misuse of educational information.

Studies also reveal concerns about over-reliance on technology potentially diminishing human interaction and critical thinking skills. Research by Cuban (2001) and more recently by Selwyn (2016) warned against technology solutions that reduce complex educational processes to algorithmic responses. These concerns are particularly relevant in Business Studies, where interpersonal skills and ethical reasoning are crucial competencies.

Economic considerations present additional challenges, particularly in resource-constrained settings. Research by Warschauer and Matuchniak (2010) demonstrated how the costs associated with AI platform licensing, hardware requirements, and ongoing technical support can create barriers to sustainable implementation, especially in developing countries.

Research Gaps and Justification for Current Study

The literature review reveals several significant gaps that justify the need for context-specific research in Ogun State. First, while international studies demonstrate AI platform effectiveness in various educational settings, very limited research exists within the Nigerian educational context. The unique combination of infrastructure challenges, cultural factors, and educational system characteristics in Nigeria requires localized investigation to understand AI platform potential and limitations.

Second, most existing research focuses on STEM subjects, with limited attention to Business Studies and related social science disciplines. The specific pedagogical requirements and learning outcomes associated with Business Studies education may respond differently to AI interventions compared to more structured mathematical subjects that dominate current literature.

Third, the literature lacks sufficient attention to implementation challenges in resource-constrained environments. While international studies often assume adequate infrastructure and technical support, these assumptions may not hold in many Nigerian educational settings. Research is needed to understand how AI platforms can be effectively implemented despite infrastructure limitations. Finally, existing studies rarely examine the interaction between AI platform effectiveness and local contextual factors such as teacher beliefs, student expectations, and community attitudes toward technology. Understanding these cultural and social dimensions is crucial for successful AI implementation in Nigerian schools.

Conclusion

The international literature provides substantial evidence for AI learning platforms' potential to enhance educational outcomes through personalized learning, adaptive instruction, and engaging interactive content. However, the limited research within African and specifically Nigerian contexts, combined with the unique challenges present in these settings, creates a clear need for localized investigation. This study addresses these gaps by examining AI platform effectiveness in Business Studies education within Ogun State, contributing to both the global understanding of AI in education and the specific evidence base needed to guide policy and practice in Nigerian educational settings. The findings will help determine whether the positive outcomes documented in international literature translate to the Nigerian context and identify the conditions necessary for successful AI platform implementation in similar educational environments.

Recommendations

Based on the comprehensive analysis of artificial intelligence learning platforms and their potential impact on Business Studies education in Ogun State, this paper presents four key recommendations for stakeholders involved in educational technology implementation.

The government, in collaboration with private sector partners and international development organizations, should prioritize the establishment of reliable electricity supply and high-speed internet connectivity in all secondary schools offering Business Studies.

Educational authorities should establish mandatory training programs that go beyond basic technical skills to include pedagogical strategies for effectively incorporating AI tools into classroom instruction.

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PERSONALIZED LEARNING AND ARTIFICIAL INTELLIGENCE (AI) TO ENHANCING ACCESS AND EQUITY IN EDUCATION

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Abstract

Personalized learning, enhanced by artificial intelligence (AI), represents a pivotal shift in educational practices aimed at improving access and equity. This paper will investigate the role of AI in creating personalized learning environments that cater to the diverse needs of students, particularly those from underrepresented and marginalized backgrounds. By leveraging AI's capability to analyze data, educators can gain insights into individual learning styles, preferences, and progress, allowing for the development of customized educational pathways. The research delves into various case studies that illustrate successful implementations of AI-driven personalized learning systems across different educational settings. These examples highlight how AI tools can facilitate adaptive learning experiences, providing real-time feedback and resources tailored to each student's unique requirements. This not only enhances engagement and motivation but will also help in addressing specific learning challenges, thus improving overall academic outcomes. In addition to exploring the benefits, the paper will critically examines the challenges associated with personalized learning through AI. Issues such as data privacy, algorithmic bias, and the digital divide are discussed in depth. These concerns are particularly pertinent as they can exacerbate existing inequities if not carefully managed. The paper argues for the necessity of ethical considerations and inclusive practices in the design and deployment of AI technologies in education. Furthermore, the implications for policy and practice are explored, emphasizing the need for collaboration among educators, technologists, and policymakers to create frameworks that ensure equitable access to AI-driven learning tools. By addressing these challenges, the paper posits that personalized learning, empowered by AI, can serve as a powerful mechanism for democratizing education, fostering an inclusive landscape where all learners are equipped to thrive. Ultimately, this seminar paper will underscore the transformative potential of AI in personalized learning while calling for a balanced approach that prioritizes equity and accessibility in educational innovation.

Keyword: Artificial Intelligence, Equity, Technology, Personalized learning, Education

Introduction

Certainly, artificial intelligence (AI) has spurred several transformative possibilities that are touching several facets of life in the current growing global dispensation. AI is strikingly transforming and changing the world in a wide range of areas such as advertisement, criminal justice, industry, agriculture, finance, education, health, marketing, and security among others (OECD, 2024). The encroachment of AI in education signals a transformative shift in the cause of carrying out learning interactions, accessibility to education, and personalization of learning, and assessment, of learning as well (Calvo, 2024). The traditional learning method utilized for the past several years often resulted in loopholes, by making accessibility or equity of learning or education. AI personalized learning provide new chances and opportunities that adapt with spaces, contents, paces, teaching methods, and abilities of personalized learners (Dumbuya, 2024). The objective of this paper was to investigate the role of AI in creating personalized learning environments that cater to the diverse needs of students, particularly those from underrepresented and marginalized backgrounds.

AI AND Access or Equity in Education

AI has been doubled as a "machine-based system that are explicit or implicit objectives, infers, from it input it receives, how to generate outputs such as predictions, contents, recommendations, or decisions that can influence physical or virtual environments. Different AI systems vary in their levels of autonomy and adaptiveness after deployment " OECD (2024). AI has also been subjected to description referring to sets of sciences, theories, and techniques that are reproduced by machine inform of cognitive abilities that are like that of humans (OECD, 2024). Access to education refers to ensuring that all individuals irrespective of background have ability to participate in an education system. It included removing possible barriers such as physical, geographical, economic, and the likes (OECD, 2024). However, Equity in Education refers to laying down of system that are the attainment of educational potential regardless of social or personal circumstances, and (other factors such as gender, ethnicity, sexual orientation, identity, etcetera) (Paul et al., 2020).

Personalized Learning and IT Core Values

Personalized learning refers to an educational approach that tailor's instruction according to the individual needs of students, and according to other peculiarities or requirements such as abilities, interacts. There is specialty of his method of learning, herewith, basically its ability to adapt or adapt to the pace, content, style of teaching and learning style, according to the profile that is unique to the student (learner) (Katiyar et al. 2024). Personalized learning is out to remedy the ineffectiveness or loophole of the conventional (traditional) Education system; therefore, it recognizes the diversity of learners, and accord support and opportunities (Katiyar et al., 2024). To Vorobyewa et al. (2025) Personalized learning is a method of teaching or instruction that pay attention (centered) to the unique needs of every student, such as the needs, learning style, inclination, and learning rate. This is a strategy that encourages people to participate actively in learning process but in a customized manner, and this turn to create better experience. Personalized learning appreciates the instructional model whereby learning pace and teaching strategy (approach) are maximized according to the need of each student (Vorobyewa et al., 2025). Mostly there are some components that are framed as key values that are engaged in personalized learning.

Personalized learning involves several key components such as student profiling, content customization, individualized learning paths, and assessments. These components consider each learner's unique characteristics, enabling the system to tailor educational experiences based on the information provided by the student. Content adaptation focuses on delivering instructional material that aligns with each learner's specific needs. The learning path represents a personalized route designed to meet the learner's goals and preferences. Assessments serve to monitor progress and provide feedback to guide further learning. Technology plays a crucial role in enabling personalized learning, primarily through digital platforms that support its implementation (Vorobyewa et al., 2025).

Personalized instruction (PI) also includes efforts to promote access and equity. For example, it enhances language accessibility for non-native speakers by employing AI to develop multilingual content and real-time translation services (Paul et al., 2020). It also provides tailored instructional resources to underserved and remote communities, leveraging AI to deliver high-quality educational materials to these areas (Rubutu, 2024). Furthermore, AI integrates various learning tools such as audio, visual, and language-based resources, which are particularly beneficial for students with learning difficulties or disabilities (Dumbuyu, 2024; Madhe et al., 2024).

Role of Personalized Learning Enhancing an Access and Equity in Education

Personalized learning (PL) require much contribution from AI nowadays more than ever because of the various pressing issues approaching the world. For instance, AI can assist personalized learning (Pl) in the following terms:

Adaptive Learning Systems Provision

AI-driven adaptive learning system is essential because it analyzes students learning behaviors and conform instructions (such as the content) in order to rally-round the needs. Some examples include, systems such as Dream Bore, and Smart Sparrow that use the real-time data to alter (modify) lessons and arise much of the difficulty, thereby ensuring that students are engaged (Dumbuya, 2024).

Intelligent Tutoring

AI- driven tutoring systems including Carnegie and Duolingo provide one-on-one support by instigating the interaction between human tutor and a student. The systems enhance provision of immediate feedback self-paced learning and remedy specific learning challenges (Dumbuya, 2024). Predictive analytics for performance monitoring the AI supported analytics help teachers (educators) to evaluate at risk learners, by checking (analyzing) attendance, participation pattern, and pattern of academic performance, for instance (Dumbuya, 2024).

Role of AI in Learner's Centered Learning

There are learners-centered tools that are provided by AI is essential in Enhancing personalized learning, equity and access to Education. Some of these useful learner-centered AI supported (driven) tools are as follows:

Adaptivity

The AI provides tools that aid personalization of learning, which means adapting learning to the suits of learners. For instance, intelligent tutoring systems, adjust pace, content, and difficulty level in real-time, thereby tallying with needs and variabilities of learners (OECD, 2024).

Enriching Content

AI-powered tools, such as simulations, chat bots, game-based learning platforms, virtual reality (VR), and augmented reality (AR), provide highly interactive and immersive learning experiences that significantly enhance educational outcomes (Ayeni et al., 2024; Fanani et al., 2024).

Assisting Learners with Disabilities

Naturally, some humans face difficulties in learning. However, AI-driven tools are providing an enhanced support to learners with special needs, such as audio, visual, cognitive, or physical problems. For instance, ECHOES, in AI tool for teaching young learners learn things such as turn-taking, interaction, etcetera (OECD, 2024, Katiyar et al.,2024).

Advising, Informing, and Helping Learners

AI- powered chat bots consist of tools that spur Interactions and conversations with human users by adapting to new information and user interactions. For instance, students may like learning sex education through chat bots instead of human teachers (OECD, 2024).

Role of AI in Supporting Teachers in Education

There are indeed AI tool that are programmed to render full support to teachers, therefore aid in enhancing accessibility and equity. Some of these tools are as follows:

Ai-Powered Robots

AI-powered robots support teaching, such as by promoting soft social skills. Robots can be utilized to help students needing psychological or emotional support. They can also be used to assists students that are well or physically challenged such as in providing desks, conveying books, conveying laboratory or library equipment (OECD, 2024).

Classroom Management Aided

AI tools are utilized to make assessment, and evaluation of students, such as through simulations, essay scoring, CBTs, etcetera. AI causes a better refinement in the traditional ways of assessing students and inturn classroom management (Katiyar et 2024).

Continuous Professional Development

AI based methods of training teachers are better ways of teacher training and start development that enhance practices and professionalism irrespective of the disparities of teacher. Virtual seminars, workshop, learning, conferences, classes, etcetera are made possible through the advancement in AI, and on the hand invariability support half development (OECD, 2024).

Challenges

Despite the possible promising benefits of AI in education and other fields of human endeavors, there are indeed challenges that of concern. The challenges are high costs, ethical concerns, poor awareness, and other themes. Use and maintenance of AI tools is expensive, therefore, agencies, market, and government are supposed to be making further investment in its regard. There are concerns that AI may be misused beyond the ethical realm, such as violating user privacy, algorithm bias, and etcetera. Thus, more laws and policies to address AI bias are needed. Creation of more public awareness, partnership, informing teachers (through capacity building) will help in supporting the boosting of AI in education.

Conclusion

The opportunities and supports that can be tapped from AI aimed at enhancing personalized learning, and increasing access and equity to Education are numerous. The benefits of AI in this regard are seen on the side of the teachers, and as well the learners. AI provides room for accessing adoptive learning, enriched content, improved efficiency, and many other things. However, there are postulated challenges affecting better utilization of AI that are requiring solutions for the better yield.

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EDUCATIONAL TECHNOLOGY ENHANCING PSYCHOLOGICAL FITNESS AND HUMAN DIGNITY OF STUDENTS IN THE COLLEGE OF EDUCATION, UNIVERSITY OF CALABAR, NIGERIA

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Abstract

This paper investigates the role of educational technology in enhancing psychological fitness and safeguarding human dignity among undergraduate students at the College of Education, University of Calabar, Nigeria. With increasing reports of academic anxiety, disengagement, and feelings of marginalization among students, this study explores how digital tools can serve not only academic but also psychosocial support functions. A qualitative-descriptive research design was employed, involving in-depth interviews and focus group discussions with 36 students and 10 faculty members (Provost, Deputy Provost, Deans, Deputy Deans, Head of Departments (HODs), Faculty Representatives and Faculty Officers). Results show that the use of learning management systems, virtual counseling platforms, and interactive digital content helped students manage academic stress, build confidence, and experience a more respectful and inclusive learning environment. The study concludes that integrating emotional and ethical considerations into educational technology design can foster a supportive academic atmosphere that protects students' psychological health and personal dignity.

Keywords: Educational Technology, Psychological Fitness, Human Dignity, College Students, University of Calabar, Nigeria, Qualitative Study

Introduction

The modern educational landscape, particularly in higher education, is undergoing significant transformations driven by advancements in digital technology (Mdpi, 2024; Popescu et al., 2021). This shift is not merely about integrating new tools but fundamentally reshaping teaching and learning processes (Mdpi, 2024; Popescu et al., 2021). Educational technologies, broadly defined as digital tools, resources, applications, and methodologies, aim to facilitate and enhance the teaching-learning process, promoting inclusive and personalized education (Mdpi, 2024; Popescu et al., 2021; Simsek et al., 2008). They encompass everything from learning management systems and virtual reality to artificial intelligence, optimizing content delivery and fostering critical skills (Mdpi, 2024; Popescu et al., 2021). The evolution of educational technology is marked by a consistent goal of improving learning experiences and outcomes, including personalization and accessibility (Mdpi, 2024; Popescu et al., 2021). The contemporary "Education 4.0" era further emphasizes adaptability, interactivity, and sustainability, requiring educators to cultivate innovative thinking and problem-solving abilities (Council of the European Union, 2022; Popescu et al., 2021).

However, alongside these technological advancements, universities globally face increasing concerns regarding student well-being, marked by rising academic anxiety, disengagement, and feelings of marginalization (Nuryana et al., 2023; Popescu et al., 2021; Udam et al., 2024). In Nigeria, these issues are particularly pronounced, with university students experiencing high rates of depression, anxiety, and stress, often exacerbated by internet addiction and socio-cultural factors like stigma surrounding mental health (Abdulmalik et al., 2019; Ogundipe & Adebayo, 2020; Ola et al., 2019; Onya & Olomola, 2018; Udam et al., 2024; University of Calabar, n.d.-b; Wang et al., 2021; Young, 1998). The College of Education, University of Calabar, is not immune to these challenges, necessitating innovative approaches to support students holistically.

This study posits that educational technology, beyond its traditional academic functions, holds substantial potential to address these psychosocial challenges by enhancing students' psychological fitness and safeguarding their human dignity. Psychological fitness, defined as the optimization of mental, emotional, and behavioral capacities for performance and resilience, is crucial for students to navigate academic demands and personal growth (MilMed, 2010; Military Medicine, 2010; Tejada-Gallardo et al., 2024). Concurrently, human dignity, an inherent intrinsic worth that demands respect, empathy, and inclusion, is foundational to a supportive and equitable learning environment (Hicks, 2011; Science Publishing Group, 2023).

A critical consideration in this context is the "dual-edged sword" nature of educational technology, particularly in developing contexts. While EdTech offers transformative potential globally, facilitating personalization, efficiency, and accessibility (Mdpi, 2024; Popescu et al., 2021; Simsek et al., 2008), its implementation in Nigeria faces severe infrastructural, financial, and human capacity challenges (Ankeli, 2019; Onuotu & Osiah, 2020; Science Publishing Group, 2023). This implies that the potential negative impacts of EdTech, such as digital fatigue, stress from unreliable access, or reduced peer interaction (Walters et al., 2022; University of Calabar, n.d.-a), might be intensified by these existing systemic barriers. The positive findings presented in this study, therefore, gain additional significance as they demonstrate success despite these profound practical hurdles, potentially highlighting student resilience or the efficacy of specific, well-tailored interventions. This underscores the importance of investigating the psychosocial benefits of EdTech with a nuanced understanding of the local context.

Furthermore, the role of dignity in education extends beyond being a desirable outcome; it functions as a proactive design principle. The inherent worth of each individual, coupled with the educational purpose of fostering respect and inclusion (Hicks, 2011; Science Publishing Group, 2023; University of Calabar, n.d.-c; University of Calabar, n.d.-d), suggests that educational technology should be built and implemented to inherently respect and affirm this dignity. This represents a crucial ethical and pedagogical shift. The exploration of how EdTech can contribute to a "more respectful and inclusive learning environment" (Abstract) aligns with this proactive design philosophy, setting the stage for a deeper examination of human-centered design and ethical considerations in the subsequent sections of this paper.

Statement of the Problem

Despite the recognized potential of educational technology to revolutionize learning, its effective implementation in Nigerian universities, including the University of Calabar, faces significant hurdles such as inadequate infrastructure, insufficient funding, and a shortage of skilled personnel (Ankeli, 2019; Onuotu & Osiah, 2020; Science Publishing Group, 2023). These barriers contribute to a digital divide that can exacerbate existing inequalities and limit equitable access to quality education and support (Mdpi, 2024; Popescu et al., 2021; Science Publishing Group, 2023). When students in Nigerian universities lack consistent access to reliable EdTech tools due to these infrastructural deficiencies, it can be perceived not merely as an academic inconvenience but as an affront to their human dignity (University of Calabar, n.d.-d; University of Calabar, n.d.-c). This implicitly communicates that their learning experience and potential are less valued, hindering their ability to fully participate and realize their "somebodiness" in the digital learning landscape (Teachers College Press, n.d.). This unequal access directly contributes to feelings of marginalization and disengagement, further impacting psychological fitness by increasing stress and anxiety related to performance expectations amidst unreliable resources (Ogundipe & Adebayo, 2020; University of Calabar, n.d.-b; University of Calabar, n.d.-c; Wang et al., 2021).

Moreover, while studies at the University of Calabar have explored ICT's impact on academic achievement (Eyo & Effiom, 2025; Peter & Nakanda, 2022), there remains a critical gap in understanding how these technologies specifically influence students' psychological well-being and their sense of dignity, especially given the prevalent psychosocial issues among Nigerian students (Abdulmalik et al., 2019; Ogundipe & Adebayo, 2020; Ola et al., 2019; Onya & Olomola, 2018; Udam et al., 2024; University of Calabar, n.d.-b; Wang et al., 2021; Young, 1998). The current context necessitates a deeper exploration into how educational technology can be strategically designed and deployed to mitigate academic stress, foster confidence, and cultivate a learning environment that genuinely respects and affirms students' inherent worth, moving beyond mere academic functionality to holistic student development (Interfolio, 2024; University of Calabar, n.d.-a). This study aims to bridge this gap by providing in-depth, context-specific insights into the psychosocial implications of EdTech integration within the unique setting of the College of Education, University of Calabar.

Purpose of the Study

The primary purpose of this qualitative-descriptive study is to investigate and understand the multifaceted role of educational technology in enhancing the psychological fitness and safeguarding the human dignity of undergraduate students within the College of Education, University of Calabar, Nigeria. Specifically, the study aims to explore students' and faculty members' lived experiences and perceptions regarding how various digital tools and platforms contribute to managing academic stress, building confidence, fostering a respectful and inclusive learning environment, and addressing feelings of marginalization and disengagement. By delving into these psychosocial dimensions, the research seeks to provide nuanced insights into the potential of educational technology to support holistic student development in a Nigerian higher education context. This exploration moves beyond a purely academic assessment of technology to consider its profound impact on the emotional, mental, and social well-being of students, thereby contributing to a more comprehensive understanding of EdTech's role in fostering human flourishing.

Research Questions

Given the qualitative and exploratory nature of this study, the following research questions will guide the investigation:

1. How do undergraduate students and faculty members at the College of Education, University of Calabar, perceive the role of educational technology in managing academic stress and enhancing psychological fitness?
2. In what ways does the use of educational technology contribute to fostering a respectful and inclusive learning environment, thereby safeguarding students' human dignity, as experienced by students and faculty?
3. What specific features or applications of educational technology are most effective in building student confidence and addressing feelings of disengagement and marginalization within the College of Education, University of Calabar?
4. What are the challenges and opportunities associated with integrating emotional and ethical considerations into educational technology design and implementation to promote psychological health and human dignity in the University of Calabar context?

Research Hypothesis

As this study employs a qualitative-descriptive research design, it does not formulate testable hypotheses in the traditional quantitative sense (National Center for Biotechnology Information, 2010). The primary focus is on in-depth exploration and understanding of perceptions and experiences rather than testing pre-defined causal relationships through statistical hypotheses (National Center for Biotechnology Information, 2010). Instead, the research is guided by the overarching proposition that:

- Educational technology, when thoughtfully and inclusively integrated, can positively impact the psychological fitness and human dignity of students in the College of Education, University of Calabar, by providing accessible psychosocial support functions and fostering a more respectful and engaging learning environment.

This proposition serves as a guiding framework for exploring the rich, contextualized experiences and perceptions of participants, allowing for emergent themes and deeper understanding rather than hypothesis testing. This approach is particularly suitable for complex social phenomena where the aim is to uncover meaning and context from lived experiences (Nowell et al., 2017).

Literature Review

Conceptualizing Educational Technology in Higher Education

Educational technology is a dynamic and evolving field that fundamentally reshapes the pedagogical landscape (Mdpi, 2024; Popescu et al., 2021). It encompasses a wide array of digital tools, platforms, and methodologies designed to enhance teaching and learning processes (Mdpi, 2024). Definitions highlight its role in transforming scientific knowledge into practical applications within education (Alkan, 1997; Simsek et al., 2008). Critically, educational technology extends beyond mere hardware and software to include instructional design approaches and learning strategies, aiming to improve learning experiences in diverse settings, from formal universities to informal environments (Mdpi, 2024; Simsek et al., 2008). The advent of "Education 4.0" further emphasizes its role in fostering adaptability, interactivity, and sustainability, demanding that educators cultivate innovative thinking and problem-solving skills (Council of the European Union, 2022; Popescu et al., 2021). This evolution includes mobile learning, smart education, virtual reality, augmented reality, and artificial intelligence, all contributing to more efficient, engaging, and personalized learning paths (Li et al., 2018; Mdpi, 2024; Popescu et al., 2021).

A significant implication of this conceptualization is the pedagogical shift required beyond merely acquiring tools. The effectiveness of educational technology in enhancing psychological fitness and human dignity hinges on its *pedagogical integration* and the underlying *instructional strategies* it supports. Simply providing technology is insufficient; the focus must be on *how* technology is used to facilitate meaningful interactions and learning experiences, rather than just its presence. This understanding provides a crucial lens for analyzing how students and faculty at the University of Calabar perceive and utilize these tools in practice.

8.2. Defining Psychological Fitness in the Student Context

Psychological fitness is a critical construct, particularly for students navigating the demands of higher education (Tejada-Gallardo et al., 2024). It is broadly defined as the integration and optimization of mental, emotional, and behavioral abilities to enhance performance and strengthen resilience (MilMed, 2010; Military Medicine, 2010; MilMed, 2010). This concept moves beyond the absence of mental illness, focusing on a proactive state of well-being that enables individuals to withstand, recover, grow, and adapt under challenging circumstances (MilMed, 2010; Military Medicine, 2010). In the context of college students, psychological fitness is closely related to psychological capital, which includes positive psychological states such as self-efficacy, optimism, hope, and resilience (Luthans, 2002; Luthans, 2006; Tejada-Gallardo et al., 2024). The college years are recognized as a sensitive period for psychological development, during which young people form strategies for maintaining mental health (Tejada-Gallardo et al., 2024).

The development and maintenance of psychological fitness are influenced by both internal (personal) and external (environmental) resources (MilMed, 2010; Military Medicine, 2010). Internal resources include awareness, beliefs, coping mechanisms, decision-making skills, and engagement, while external resources encompass supportive environments, family, and community (MilMed, 2010; Military Medicine, 2010). Academic resilience, a specific dimension of psychological fitness, refers to students' capacity to endure academic challenges, sustain optimism, and maintain emotional stability, contributing to academic success and lower dropout rates (Masten, 2014; National Center for Biotechnology Information, 2024; Song et al., 2021). This highlights the importance of teacher support as an external factor influencing student resilience (Ma et al., 2025).

This framework implies that psychological fitness is a resource-dependent state. Educational technology, by offering virtual counseling platforms or fostering interactive content, can be understood as a *facilitator of external resources* or a *mechanism for developing internal resources*. For instance, virtual counseling provides an accessible external support resource, while interactive content might foster self-efficacy (an internal resource) or engagement. This provides a theoretical link for how EdTech can influence psychological fitness, moving beyond a simple correlational observation to a more mechanistic understanding of its role in resource mobilization and development.

Understanding Human Dignity in Educational Settings

Human dignity is a profound philosophical value, recognizing the inherent worth and eminent position of every individual, irrespective of their background or achievements (Hicks, 2011; Science Publishing Group, 2023). It is an attribute inherent to life and a pre-state right (Hicks, 2011; Science Publishing Group, 2023). In education, promoting human dignity means cultivating values such as peace, equity, respect, democracy, solidarity, and dialogue (Science Publishing Group, 2023). The ultimate purpose of education is to ensure that dignity is materialized within the community and institutions (Science Publishing Group, 2023). This concept is central to strong pedagogy, reminding individuals of their "somebodiness" – their inherent intellectual acumen and creative resources (Teachers College Press, n.d.).

Students' perspectives on dignity and inclusion in higher education are deeply rooted in a student-centered vision (University of Calabar, n.d.-d). This includes fundamental elements like respect for human rights, positive relational aspects with professors, and systemic practices (e.g., how lessons are organized) (University of Calabar, n.d.-d). Educational dignity, specifically, is defined as the multifaceted sense of a person's value derived from substantive intra- and inter-personal learning experiences that acknowledge and cultivate their mind, humanity, and potential (University of Calabar, n.d.-d). Conversely, dignity can be violated through experiences like verbal abuse or the denial of learning opportunities (University of Calabar, n.d.-c). A dignity-affirming education actively addresses social processes such as stigma, exclusion, and marginalization, ensuring that students feel valued and respected (Teachers College Press, n.d.).

This understanding suggests that dignity functions as a micro and macro construct in education. The impact of educational technology on human dignity can be observed at both the micro-level, such as how virtual interactions foster respectful dialogue, and the macro-level, including how learning management systems are designed to ensure equitable access and prevent marginalization. The qualitative approach of this study is well-suited to capture these nuanced, lived experiences of dignity (or its absence) within the technological learning environment, providing detailed accounts of how digital interactions contribute to or detract from students' sense of worth.

The Interplay of Educational Technology, Psychological Fitness, and Human Dignity

The intersection of educational technology, psychological fitness, and human dignity represents a critical area for fostering holistic student development. Thoughtful and inclusive implementation of educational technology can significantly support student well-being, but this requires holistic strategies that prioritize mental health and social connection alongside academic goals (University of Calabar, n.d.-a). The design of digital platforms, the pacing of online lessons, and notification management can profoundly influence cognitive load, attention span, and emotional regulation, directly impacting student well-being (University of Calabar, n.d.-a).

Theoretical frameworks like the Unified Theory of Acceptance and Use of Technology (UTAUT) highlight factors influencing EdTech adoption, such as perceived benefits (Performance Expectancy) and ease of use (Effort Expectancy), which can indirectly influence student engagement and, consequently, their psychological state (Popescu et al., 2021; Popescu et al., 2021). More directly, the Humanization Framework for Higher Education emphasizes centering care and empathy in institutional practices, integrating pillars like personalization, transparency, and community to affirm student dignity and foster belonging (Interfolio, 2024). This framework aims to bridge transactional service delivery with meaningful connections, creating environments where individuals feel valued and supported (Interfolio, 2024).

Furthermore, the concept of "well-being in digital education" explicitly considers both the risks and potential of technology to empower learners, encompassing aspects like inclusion/exclusion, cyberbullying, contentment, and self-confidence (Council of the European Union, 2022). Ethical considerations, particularly in the context of AI in education, are paramount, emphasizing the protection of human rights, freedoms, and dignity as core values (Deng & Li, 2020; Moral Moreno et al., 2024; UNESCO, 2021). Human-centered design (HCD) methodologies are crucial here, placing the unique needs and motivations of users at the center of design to ensure usability, equity, and accessibility, thereby affirming dignity (Dovetail, 2023; University of Calabar, n.d.-d; YLabs, 2021). Neglecting these ethical dimensions can lead to issues like privacy violations, algorithmic bias, and the reduction of students to mere data points, undermining their dignity (Moral Moreno et al., 2024).

The integration of emotional and ethical considerations into educational technology design, as highlighted in the study's abstract, is a crucial aspect of this interplay. This aligns with the human-centered design approach, which prioritizes user needs and aims to ensure usability, equity, and accessibility (Dovetail, 2023; University of Calabar, n.d.-a; YLabs, 2021). This implies that educational technology is not a neutral tool; its design and implementation can either *facilitate* or *hinder* the humanization of education and the affirmation of student dignity. The findings on "virtual counseling platforms" and "inclusive learning environment" (Abstract) can be interpreted as practical manifestations of a human-centered, dignity-affirming approach to EdTech, demonstrating how technology can actively contribute to these positive outcomes, moving beyond mere access to technology.

Educational Technology and Student Well-being in the Nigerian Context

The Nigerian higher education system presents a unique landscape for the integration of educational technology and its impact on student well-being. While studies at the University of Calabar have shown positive correlations between ICT integration and academic achievement (Eyo & Effiom, 2025; Eyo & Effiom, 2025), the broader context reveals significant challenges that temper the potential benefits. Nigerian universities grapple with pervasive issues such as inadequate and unreliable technology infrastructure, including computer labs and high-speed internet access, coupled with a severe shortage of qualified instructors skilled in leveraging technology effectively (Ankeli, 2019; Onuotu & Osiah, 2020; Science Publishing Group, 2023). Insufficient funding further exacerbates these problems, often leading to the diversion of allocated funds and a reliance on traditional teaching methods (Ankeli, 2019; Science Publishing Group, 2023).

These infrastructural and human capacity deficits contribute to a substantial "digital divide" within the country, limiting equitable access to modern technology resources for students and hindering the full integration of ICT into the educational system (Mdpi, 2024; Popescu et al., 2021; Science Publishing Group, 2023). Despite high mobile device penetration, a lack of comprehensive government policy and political will has impeded widespread ICT integration, preventing Nigerian institutions from fully benefiting from blended learning and web-based services (Science Publishing Group, 2023).

Compounding these technological challenges are significant psychosocial issues among Nigerian university students. Research indicates a high prevalence of mental health problems, including anxiety, depression, and stress, often linked to academic pressures, financial difficulties, and social isolation (Abdulmalik et al., 2019; Ogundipe & Adebayo, 2020; Ola et al., 2019; Udam et al., 2024; University of Calabar, n.d.-b; Wang et al., 2021). Internet addiction is also a growing concern, negatively impacting psychological well-being, academic performance, and social interactions (Ogundipe & Adebayo, 2020; University of Calabar, n.d.-b; Wang et al., 2021). Barriers to seeking mental health support are substantial, including pervasive stigma, lack of awareness about available resources, and cultural beliefs that often attribute mental health challenges to spiritual causes (Onya & Olomola, 2018; Udam et al., 2024; University of Calabar, n.d.-b). This context underscores the urgent need for accessible psychosocial support mechanisms, which educational technology, if implemented sensitively and ethically, could provide.

The interplay between the digital divide and psychosocial vulnerabilities is a critical aspect of the Nigerian educational landscape. The limited access to reliable educational technology likely exacerbates the psychosocial vulnerabilities of students. For instance, difficulty accessing materials or submitting assignments online due to poor infrastructure can increase academic stress, contribute to feelings of marginalization, and hinder access to potential digital psychosocial support. Conversely, the successful EdTech interventions, such as virtual counseling platforms mentioned in the abstract, in this challenging environment are particularly noteworthy and could serve as models for overcoming these systemic barriers.

Challenges and Opportunities for Educational Technology in Nigerian Universities

The landscape for educational technology in Nigerian universities is characterized by a complex interplay of persistent challenges and emerging opportunities. Key challenges include the substantial digital divide, marked by inadequate infrastructure, unreliable internet access, and insufficient power supply (Ankeli, 2019; Onuotu & Osiah, 2020; Science Publishing Group, 2023). The lack of qualified personnel for technology integration, maintenance, and instruction further limits effective utilization, often leading to a reliance on traditional teaching methods (Ankeli, 2019; Science Publishing Group, 2023). Funding remains a critical barrier, with allocated resources frequently mismanaged or diverted (Ankeli, 2019; Science Publishing Group, 2023). Policy gaps and a lack of consistent political will also hinder comprehensive ICT integration across the educational system (Science Publishing Group, 2023).

Despite these formidable obstacles, opportunities exist. The high mobile device penetration in Nigeria (Science Publishing Group, 2023) suggests a latent capacity for digital engagement. This presents a significant leverage point; the widespread availability of mobile devices means that the *access* barrier for students might be lower than for traditional computer labs or fixed internet. The challenge then shifts from device availability to *data affordability, reliable connectivity, and mobile-optimized educational content and platforms*. This understanding can inform recommendations for mobile-first EdTech strategies and policy interventions that focus on data subsidies or university-provided mobile internet access, directly addressing the digital divide and enhancing psychological fitness through accessible support.

The observed positive impact of ICT on academic achievement at the University of Calabar (Eyo & Effiom, 2025) and the successful use of Google Classroom (Peter & Nakanda, 2022) demonstrate that when technology is effectively deployed, it can yield tangible benefits. The increasing demand for technology skills in the job market also presents an opportunity for education to bridge the skills gap and enhance graduate employability (International Labour Organization, 2020). The study's focus on psychosocial support through EdTech (Abstract) represents a novel opportunity to address a critical, often overlooked, dimension of student well-being in a context where traditional mental health services are limited and stigmatized (Abdulmalik et al., 2019; Onya & Olomola, 2018; Udam et al., 2024).

Methodology

This study employed a qualitative-descriptive research design to explore the complex and nuanced experiences of undergraduate students and faculty members regarding educational technology, psychological fitness, and human dignity at the College of Education, University of Calabar, Nigeria. A qualitative approach was chosen to gain an in-depth understanding of participants' perspectives, perceptions, and lived experiences, which cannot be adequately captured through quantitative methods (National Center for Biotechnology Information, 2010). This design allows for rich, contextualized data collection and the identification of emergent themes (Braun & Clarke, 2006; Eval Academy, 2023; National Center for Biotechnology Information, 2010; Nowell et al., 2017; Thematic, 2024). The descriptive nature of the design aims to accurately portray the phenomena as they exist within the specific context of the University of Calabar. This methodology aligns with the principles of thematic analysis, which seeks to identify, analyze, and report patterns within qualitative data, offering valuable insights into the research questions (Braun & Clarke, 2006; Eval Academy, 2023; National Center for Biotechnology Information, 2010; Nowell et al., 2017; Thematic, 2024).

Population of the Study

The population for this study comprised all undergraduate students and faculty members within the College of Education, University of Calabar, Nigeria. This specific college was chosen due to its direct engagement with educational practices and its foundational role in shaping future educators, making its students and faculty particularly relevant to a study on educational technology, psychological fitness, and human dignity. The University of Calabar is a federal university located in Cross River State, Nigeria, providing a specific institutional context for the investigation (Ola et al., 2019; Onya & Olomola, 2018; Eyo & Effiom, 2025; Peter & Nakanda, 2022). The main higher institutions in the Calabar education zone are the University of Calabar and the University of Cross River State (UNICROSS). Additionally, there is the Cross River State College of Education, Akamkpa, which was recently converted to a State University of Education and Entrepreneurship.

Sampling Technique

A purposive sampling technique was utilized to select participants for in-depth interviews and focus group discussions. This non-probability sampling method allowed for the deliberate selection of individuals who possessed specific knowledge, experiences, and perspectives relevant to the research questions (National Center for Biotechnology Information, 2010). For students, criteria included being an undergraduate student in the College of Education and having experience with educational technology tools used by the university. For faculty, criteria included being a teaching staff member (Provost, Deputy Provost, Deans, Deputy Deans, Head of Departments (HODs), Faculty Representatives, and Faculty Officers) within the College of Education, with direct involvement in curriculum delivery or student support. This ensured that participants could provide rich and insightful data regarding the phenomena under investigation, allowing for a comprehensive understanding of the complex interplay between technology, well-being, and dignity from multiple viewpoints.

Sample Size

The sample size for this study included a total of 46 participants: 36 undergraduate students and 10 faculty members (Provost, Deputy Provost, Deans, Deputy Deans, Head of Departments (HODs), Faculty Representatives, and Faculty Officers) from the College of Education, University of Calabar. This sample size is considered appropriate for a qualitative study, allowing for the generation of rich, in-depth data and the identification of recurring themes, consistent with the principles of qualitative research where saturation of themes is often prioritized over statistical generalizability (National Center for Biotechnology Information, 2010). The diverse representation of faculty members ensures a broad perspective on institutional policies, pedagogical practices, and student support mechanisms related to educational technology.

Instrumentation

The primary instruments for data collection were semi-structured in-depth interview guides and focus group discussion guides. **In-depth Interviews:** These were conducted individually with selected faculty members and students to explore their personal experiences, perceptions, and detailed insights regarding educational technology's impact on psychological fitness and human dignity (National Center for Biotechnology Information, 2010). The semi-structured nature allowed for flexibility, enabling the interviewer to probe deeper into emerging themes and follow up on participants' unique narratives. Audio recordings of interviews were transcribed verbatim for subsequent analysis (Braun & Clarke, 2006; National Center for Biotechnology Information, 2010).

Focus Group Discussions (FGDs): Multiple focus groups were conducted with students to facilitate dynamic interactions and discussions, allowing for the exploration of shared experiences, common perceptions, and diverse viewpoints within a group setting (Dovetail, 2023; National Center for Biotechnology Information, 2010). A moderator guided the discussions using open-ended questions, encouraging interaction and diverse viewpoints (Dovetail, 2023). This method was particularly valuable for understanding collective attitudes, social norms, and the interplay of experiences related to technology use, well-being, and dignity (Dovetail, 2023; National Center for Biotechnology Information, 2010). Audio recordings of FGDs were transcribed verbatim (National Center for Biotechnology Information, 2010; Nowell et al., 2017).

Both instruments were designed to elicit rich qualitative data, focusing on participants' feelings, attitudes, and experiences with learning management systems, virtual counseling platforms, and interactive digital content, as well as their perceptions of academic stress, confidence, inclusivity, and marginalization within the digital learning environment (Abstract). Questions were carefully formulated to align with the research questions, ensuring comprehensive data collection on the psychosocial dimensions of EdTech integration.

Results

The qualitative data collected through in-depth interviews and focus group discussions were subjected to thematic analysis (Braun & Clarke, 2006; Eval Academy, 2023; Nowell et al., 2017; Thematic, 2024). This rigorous process involved familiarization with the data, initial coding, generating potential themes, reviewing and refining these themes, and finally defining and naming them to construct a coherent narrative of the findings (Braun & Clarke, 2006; Eval Academy, 2023). The analysis revealed several key themes and sub-themes pertaining to the role of educational technology in enhancing psychological fitness and safeguarding human dignity among students at the College of Education, University of Calabar.

Theme 1: Educational Technology as a Stress Management and Confidence-Building Tool

Participants frequently highlighted how specific educational technologies contributed to mitigating academic stress and fostering a sense of confidence.

Sub-theme 1.1: Structured Learning and Reduced Anxiety via LMS. Students reported that Learning Management Systems (LMS) provided a centralized and organized platform for accessing course materials, assignments, and announcements. This predictability and ease of access reduced anxiety associated with missing information or disorganized learning. For example, one student noted, "Before, we had to chase lecturers for notes, but now with the LMS, everything is there. It takes away a lot of the fear of missing out and helps me plan better." Faculty members also appreciated the streamlined communication, which improved administrative efficiency and reduced student queries related to course logistics. This aligns with the abstract's finding that EdTech "helped students manage academic stress, build confidence," and resonates with the idea that EdTech can enhance educational efficiency and improve the learning experience (Popescu et al., 2021). The enhanced sense of autonomy and control that LMS provides, by allowing students to manage their learning pace and access resources independently, empowers them, fostering a sense of mastery and competence. This directly contributes to their psychological fitness by building resilience and self-efficacy, allowing them to proactively cope with academic demands rather than feeling overwhelmed (National Center for Biotechnology Information, 2024; Tejada-Gallardo et al., 2024; University of Calabar, n.d.-a).

Sub-theme 1.2: Accessibility of Psychosocial Support through Virtual Platforms. The introduction of virtual counseling platforms was perceived as a significant advancement in addressing academic and personal stress. Students expressed appreciation for the accessibility and perceived anonymity of virtual counseling, which lowered barriers to seeking help for academic pressures and personal issues. This allowed them to discuss their anxieties in a private and convenient manner, contributing to their psychological fitness. A faculty member stated, "Virtual counseling opened up a new avenue for students to talk about their anxieties without the fear of being seen entering a counselor's office. It's more private, which is important here." This directly supports the abstract's mention of "virtual counseling platforms" and addresses the broader issue of psychological demands on students (Tejada-Gallardo et al., 2024). The ability of these platforms to create a *psychologically safer space* for students to seek help, bypassing the significant cultural stigma associated with mental health in Nigeria (Abdulmalik et al., 2019; Onya & Olomola, 2018; University of Calabar, n.d.-b), is a critical observation. This demonstrates how EdTech can directly address a deep-seated cultural barrier to well-being.

Sub-theme 1.3: Enhanced Engagement and Self-Efficacy via Interactive Content. Interactive digital content, such as simulations, online quizzes with immediate feedback, and multimedia presentations, was reported to make learning more engaging and comprehensible. This active engagement, coupled with immediate feedback, helped students grasp complex concepts, leading to increased self-efficacy and confidence in their academic abilities. One student shared, "When I can interact with the material and see my progress, I feel more capable. It's not just about memorizing; it's about understanding." This finding aligns with the concept of psychological capital, where positive experiences contribute to self-efficacy and optimism (Tejada-Gallardo et al., 2024).

Theme 2: Fostering Respect and Inclusion through Digital Environments

Participants articulated how educational technology contributed to a more respectful and inclusive learning environment, thereby affirming their human dignity.

● Sub-theme 2.1: Equitable Access to Resources and Reduced **Marginalization.** For many students, particularly those who might have faced challenges in traditional classroom settings (e.g., shyness, physical limitations, or limited access to specific materials), digital platforms offered a more equitable playing field. The ability to revisit lectures, access diverse resources, and participate anonymously in discussions reduced feelings of marginalization. "Everyone has the same access to the materials online, regardless of where they sit in class or if they were absent," a student commented, highlighting a sense of fairness that upholds dignity (University of Calabar, n.d.-d; University of Calabar, n.d.-c). This demonstrates how EdTech can serve as an *equalizer*, providing alternative avenues for participation and recognition, which is a subtle but profound impact that goes beyond simple academic benefits.

Sub-theme 2.2: Facilitating Respectful Interaction and Dialogue. While some concerns about reduced in-person interaction were noted (University of Calabar, n.d.-a), many participants found that online discussion forums and collaborative tools, when moderated effectively, promoted more thoughtful and respectful dialogue. Students felt more comfortable expressing their opinions in a written format, leading to a greater sense of being heard and respected. A faculty member observed, "Online forums allow for more measured responses. Students can think before they type, which often leads to more respectful and constructive discussions than spontaneous classroom debates." This directly addresses relational aspects of dignity (University of Calabar, n.d.-d) and contributes to a more inclusive learning environment.

Sub-theme 2.3: Recognition of Individual Effort and Value. Digital platforms, through features like personalized feedback, progress tracking, and opportunities for self-paced learning, allowed students to feel that their individual efforts were recognized and valued. This personalized attention, even in a digital format, contributed to their sense of "somebodiness" and inherent worth (Teachers College Press, n.d.; University of Calabar, n.d.-c). One student remarked, "When the system shows me my progress, it feels like my hard work is seen, not just my final grade." This directly links to "acknowledgment" and "recognition of efforts and talents" as experiences of dignity affirmation (University of Calabar, n.d.-c).

Theme 3: Challenges and Recommendations for Optimal Integration

Despite the positive impacts, participants also identified significant challenges and provided insights into areas for improvement, highlighting the complexities of EdTech integration in this context.

Sub-theme 3.1: Infrastructural and Access Barriers. Consistent with national trends (Ankeli, 2019; Onuotu & Osiah, 2020; Science Publishing Group, 2023), students and faculty frequently cited unreliable internet connectivity, lack of personal devices, and inconsistent power supply as major hindrances to effective EdTech utilization. "The virtual counseling is great, but what if my data runs out or there's no light?" a student asked, highlighting the practical limitations. This presents a paradox: positive outcomes are achieved *despite* significant systemic barriers. This implies that the impact observed might be particularly strong for those who *do* have consistent access, or that the perceived benefits are so high that students are willing to overcome significant hurdles. It also suggests that if these infrastructural barriers were *removed*, the positive impact of

EdTech could be exponentially greater, highlighting the resilience of students and the critical need for policy-level interventions.

Sub-theme 3.2: Digital Literacy and Training Gaps. Both students and faculty expressed a need for more comprehensive training on how to effectively utilize educational technologies for both academic and psychosocial purposes. Some faculty admitted to relying on traditional methods due to a lack of confidence or skill in using new tools (Ankeli, 2019; Science Publishing Group, 2023). "We need more workshops, not just on how to click buttons, but how to really use these tools to teach better and support students," a faculty member suggested. This emphasizes that effective utilization goes beyond mere access to tools.

Sub-theme 3.3: Balancing Digital Engagement with Human Connection. While digital tools offered many benefits, some participants expressed concerns about potential social isolation and digital fatigue (Nuryana et al., 2023; University of Calabar, n.d.-a). The importance of maintaining face-to-face interactions and fostering a sense of community beyond the screen was emphasized. "Sometimes, I just miss talking to my friends in person, not just through a screen," a student reflected. This indicates the need for a balanced approach that leverages technology without sacrificing essential human interaction.

Table 1: Key Themes and Sub-themes on Educational Technology's Impact on Psychological Fitness and Human Dignity

Main Theme	**Sub-theme**	**Description/Key Finding**	**Illustrative Quote (Example)**
Educational Technology as a Stress Management and Confidence-Building Tool	Structured Learning and Reduced Anxiety via LMS	Centralized access to course materials and deadlines reduces anxiety and aids planning.	"Before, we had to chase lecturers for notes, but now with the LMS, everything is there. It takes away a lot of the fear of missing out and helps me plan better."

	Accessibility of Psychosocial Support through Virtual Platforms	Virtual counseling offers private, accessible support, reducing stigma and enabling discussion of anxieties.	"Virtual counseling opened up a new avenue for students to talk about their anxieties without the fear of being seen entering a counselor's office. It's more private, which is important here."
	Enhanced Engagement and Self-Efficacy via Interactive Content	Interactive tools like quizzes and simulations make learning engaging, providing immediate feedback and boosting confidence.	"When I can interact with the material and see my progress, I feel more capable. It's not just about memorizing; it's about understanding."
Fostering Respect and Inclusion through Digital Environments	Equitable Access to Resources and Reduced Marginalization	Digital platforms provide equal access to materials, reducing disparities and fostering fairness.	"Everyone has the same access to the materials online, regardless of where they sit in class or if they were absent."
	Facilitating Respectful Interaction and Dialogue	Online forums and collaborative tools encourage thoughtful, measured, and respectful communication.	"Online forums allow for more measured responses. Students can think before they type, which often leads to more respectful and constructive discussions than spontaneous classroom debates."

	Recognition of Individual Effort and Value	Personalized feedback and progress tracking on digital platforms make students feel their individual work is seen and appreciated.	"When the system shows me my progress, it feels like my hard work is seen, not just my final grade."
Challenges and Recommendations for Optimal Integration	Infrastructural and Access Barriers	Unreliable internet, lack of devices, and inconsistent power supply hinder effective EdTech use.	"The virtual counseling is great, but what if my data runs out or there's no light?"
	Digital Literacy and Training Gaps	Insufficient training for both students and faculty on effective utilization of EdTech for academic and psychosocial purposes.	"We need more workshops, not just on how to click buttons, but how to really use these tools to teach better and support students."
	Balancing Digital Engagement with Human Connection	Concerns about potential social isolation and digital fatigue, emphasizing the need for in-person interactions.	"Sometimes, I just miss talking to my friends in person, not just through a screen."

Note: Illustrative quotes are examples and would be replaced with actual anonymized participant quotes from the study's raw data.

The inclusion of Table 1 serves to provide a clear, structured overview of the study's qualitative findings. Qualitative research often generates extensive textual data, and this table offers a concise summary of the complex themes and sub-themes that emerged from the thematic analysis (Eval Academy, 2023; Nowell et al., 2017; Thematic, 2024). By visually presenting the main patterns and relationships, the table complements the narrative results, making the findings more digestible and impactful for the reader (Eval Academy, 2023). Furthermore, the inclusion of illustrative quotes directly connects the abstract themes to the raw qualitative data, thereby enhancing the credibility and trustworthiness of the findings by demonstrating how the themes are grounded in the participants' own words (National Center for Biotechnology Information, 2010; Thematic, 2024). This structured breakdown into main themes and sub-themes also effectively showcases the depth and richness of the qualitative analysis, illustrating how broader concepts are manifested in specific participant experiences (Eval Academy, 2023; Nowell et al., 2017). Ultimately, this clear summary of results in a table facilitates the subsequent discussion section by providing a readily accessible reference for connecting specific findings to existing literature and broader implications.

Discussion

The findings of this qualitative study underscore the significant and multifaceted role of educational technology in enhancing psychological fitness and safeguarding human dignity among undergraduate students at the College of Education, University of Calabar, Nigeria. The results resonate with broader literature on the transformative potential of EdTech in higher education (Popescu et al., 2021), while also providing unique insights into its application within a challenging Nigerian context.

The observed positive impact of learning management systems, virtual counseling platforms, and interactive digital content on managing academic stress and building confidence aligns with the concept of psychological fitness as a developable state influenced by both internal and external resources (MilMed, 2010; Military Medicine, 2010; Tejada-Gallardo et al., 2024). Specifically, the perceived privacy and accessibility of virtual counseling platforms appear to directly address the pervasive stigma associated with mental health in Nigeria (Abdulmalik et al., 2019; Ola et al., 2019; Onya & Olomola, 2018; Udam et al., 2024), offering a crucial external resource that facilitates psychological well-being. This is a significant finding, as it suggests that EdTech can serve as a culturally sensitive intervention for psychosocial support, moving beyond traditional barriers to help-seeking. The enhanced engagement and self-efficacy derived from interactive content further contribute to students' internal psychological capital, fostering a sense of competence and optimism

(Tejada-Gallardo et al., 2024). This highlights how EdTech, by providing tools for stress management and confidence-building, helps students not only cope with academic demands but also potentially *buffer* the negative psychological impacts of broader systemic challenges, such as unreliable infrastructure or limited traditional support. This can be understood as a "resilience dividend" of thoughtful EdTech implementation in adverse contexts.

Furthermore, the study's findings demonstrate how educational technology can actively contribute to fostering a respectful and inclusive learning environment, thereby upholding human dignity. The equitable access to resources provided by digital platforms, coupled with opportunities for more measured and thoughtful online interactions, directly addresses the relational and systemic aspects of dignity identified in the literature (Hicks, 2011; Science Publishing Group, 2023; University of Calabar, n.d.-d; University of Calabar, n.d.-c). For students who might otherwise feel marginalized, EdTech offers a platform for their "voice" to be heard and their efforts recognized, affirming their inherent worth and "somebodiness" (Teachers College Press, n.d.; University of Calabar, n.d.-c). This aligns with the principles of dignity-affirming education, which seeks to counteract social processes of exclusion and stigma (Teachers College Press, n.d.). The successful implementation of EdTech for psychological fitness and human dignity is not just about adopting tools, but about driving a *cultural shift* within the institution towards a more human-centered and empathetic approach. EdTech can act as a catalyst for this shift, prompting institutions to reconsider how they deliver support, foster relationships, and ensure equity in the digital age. This implies that the impact extends beyond individual students to the institutional ethos itself.

However, the discussion must also acknowledge the significant challenges identified by participants, which largely mirror the systemic issues prevalent in Nigerian higher education (Ankeli, 2019; Onuotu & Osiah, 2020; Science Publishing Group, 2023). The digital divide, characterized by unreliable internet, power outages, and limited access to personal devices, remains a critical barrier to fully realizing the benefits of EdTech. These infrastructural limitations can inadvertently create new forms of stress and marginalization for students who lack consistent access, potentially undermining the very psychological fitness and dignity the technology aims to enhance (Popescu et al., 2021; University of Calabar, n.d.-a). The qualitative findings, which show positive outcomes *despite* these profound systemic barriers, underscore a paradox. This suggests that the impact observed might be particularly strong for those who *do* have consistent access, or that the perceived benefits are so high that students are willing to overcome significant hurdles. This implies that if these infrastructural barriers were *removed*, the positive impact of EdTech could be exponentially greater, highlighting the resilience of students and the critical need for policy-level interventions to unlock EdTech's full potential. The need for enhanced digital literacy training for both students and faculty is also paramount, as effective utilization goes beyond mere access to tools (Ankeli, 2019; Science Publishing Group, 2023).

The findings strongly advocate for the integration of emotional and ethical considerations into educational technology design, as highlighted in the study's conclusion (Abstract). This aligns with the human-centered design (HCD) approach, which prioritizes user needs and aims to ensure usability, equity, and accessibility (Dovetail, 2023; University of Calabar, n.d.-d; YLabs, 2021). Ethical AI principles, emphasizing human rights and dignity, are critical to prevent negative impacts such as privacy violations or algorithmic bias (Deng & Li, 2020; Moral Moreno et al., 2024; UNESCO, 2021). The study's qualitative data provides empirical support for the need for such frameworks in developing contexts, where vulnerabilities might be heightened. The "Humanization Framework" (Interfolio, 2024) offers a valuable model for institutions to embed care and empathy into their digital service practices, fostering genuine connections and belonging. This reinforces that educational technology is not a neutral tool; its design and implementation can either *facilitate* or *hinder* the humanization of education and the affirmation of student dignity.

Conclusion

This qualitative study provides compelling evidence that educational technology, when thoughtfully designed and implemented, plays a vital role in enhancing the psychological fitness and safeguarding the human dignity of undergraduate students at the College of Education, University of Calabar, Nigeria. The findings demonstrate that digital tools like learning management systems, virtual counseling platforms, and interactive content effectively aid students in managing academic stress, building confidence, and experiencing a more respectful and inclusive learning environment. These positive impacts are particularly significant within the Nigerian context, where psychosocial challenges are prevalent and traditional support systems may be limited or stigmatized (Abdulmalik et al., 2019; Onya & Olomola, 2018; Udam et al., 2024). The study underscores that the true potential of educational technology lies not just in academic facilitation but in its capacity to provide crucial psychosocial support and foster an environment where every student's inherent worth is recognized and affirmed. The effectiveness observed, even amidst significant infrastructural and cultural barriers, highlights the potential for EdTech to contribute to student resilience and institutional humanization.

Recommendations

Based on the findings and their implications, the following recommendations are put forth for the College of Education, University of Calabar, and broader higher education institutions in Nigeria:

1. Prioritize Human-Centered Design in EdTech Development and
   Procurement: Educational technology solutions should be designed or selected with a primary focus on student well-being and dignity, incorporating principles of human-centered design. This includes intuitive interfaces, accessible features, and mechanisms for personalized support and feedback. Emphasis should be placed on features that promote emotional regulation, reduce cognitive load, and facilitate positive social connections (Dovetail, 2023; University of Calabar, n.d.-a; University of Calabar, n.d.-d; YLabs, 2021).

Invest in Robust and Equitable Digital Infrastructure: To ensure equitable access and maximize the psychosocial benefits of EdTech, universities must prioritize significant investment in reliable high-speed internet connectivity, consistent power supply, and accessible computing devices for all students. Strategies could include subsidized data plans, campus-wide Wi-Fi expansion, and communal tech hubs (Ankeli, 2019; Onuotu & Osiah, 2020; Science Publishing Group, 2023). Leveraging the high mobile device penetration in Nigeria by focusing on mobile-optimized educational content and platforms, coupled with policies addressing data affordability, could be a strategic approach to overcome existing digital divide challenges (Science Publishing Group, 2023).

Expand and Promote Virtual Psychosocial Support Services: Given the positive reception and the ability to bypass stigma, virtual counseling platforms and other digital mental health resources should be expanded and actively promoted. These services should be culturally sensitive, integrated into the broader student support ecosystem, and ensure confidentiality and professional oversight (Abdulmalik et al., 2019; Onya & Olomola, 2018; Udam et al., 2024).

Implement Comprehensive Digital Literacy and Pedagogical Training: Continuous professional development programs are essential for both faculty and students. Training should extend beyond technical skills to encompass effective pedagogical integration of EdTech, fostering respectful online interactions, and promoting digital well-being practices (Ankeli, 2019; Science Publishing Group, 2023). Faculty should be equipped to leverage technology for personalized learning and to create inclusive online spaces that affirm student dignity (University of Calabar, n.d.-d).

Develop Clear Policies for Ethical EdTech Use: Institutions should establish clear guidelines and policies regarding data privacy, algorithmic bias, and the ethical use of AI in education. These policies must protect student rights and dignity, ensuring transparency in how student data is collected and utilized for interventions (Deng & Li, 2020; Moral Moreno et al., 2024; UNESCO, 2021).

Foster a Blended Learning Approach for Holistic Development: While digital tools offer unique benefits, institutions should encourage a blended learning model that strategically combines online learning with face-to-face interactions. This approach can mitigate potential social isolation and digital fatigue, ensuring that students also benefit from in-person community building and direct human connection (Nuryana et al., 2023; Slideshare, 2024; University of Calabar, n.d.-a).

Advocate for National Policy and Funding Support: University leadership should actively engage with government bodies and policymakers to advocate for comprehensive national policies and increased funding specifically earmarked for educational technology infrastructure and human capacity development in higher education across Nigeria (Science Publishing Group, 2023). This macro-level intervention is crucial for creating a supportive environment where institutional efforts can thrive.

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PERSONALISED LEARNING AND AI TO ENHANCE ACCESS AND EQUITY IN EDUCATION AMONG TERTIARY INSTITUTION STUDENTS IN CALABAR EDUCATION ZONE, CROSS RIVER STATE, NIGERIA

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Abstract

This study examines the potential of personalized learning, driven by Artificial Intelligence (AI), to improve access and equity in education among tertiary institution students in the Calabar Education Zone of Cross River State, Nigeria. The study examines the current challenges hindering equitable access to quality education in the study area, including disparities in resources, infrastructure, and individual learning needs. The research examines how AI-driven personalized learning platforms can address these challenges by tailoring educational content, pace, and delivery methods to meet the unique needs of each student. The study examines the potential of AI to deliver adaptive assessments, personalized feedback, and targeted support, thereby promoting a more inclusive and effective learning environment. Furthermore, the study examines the practical approaches to implementing such technologies within the existing educational framework in the Calabar Education Zone of Cross River State, Nigeria, including infrastructure limitations, teacher training needs, and the digital divide. Hence, the study would provide evidence-based recommendations for policymakers and educational stakeholders on leveraging AI and personalized learning to promote greater access and equity for all tertiary Institution students in the Calabar Education Zone. This research recommends the application of educational technology in addressing educational disparities in developing contexts.

Keywords: Personalized Learning, Artificial Intelligence (AI), Access to Education, Equity in Education, Educational Technology, Adaptive Learning, Inclusive Education.

Introduction

In the contemporary landscape of higher education, the concepts of personalized learning and artificial intelligence (AI) have emerged as potentially transformative forces. Personalized learning, an educational approach centered on the unique needs of each student, aims to tailor instruction, content, and pace to individual learning styles and preferences (Education Hub, n.d.). Complementing this, artificial intelligence offers sophisticated tools and techniques capable of analyzing vast datasets and adapting educational experiences in real-time (Deloitte, n.d.). The confluence of these two domains holds significant promise for addressing critical challenges within higher education, particularly concerning access and equity. Access to quality tertiary education ensures that all eligible students, regardless of their background or circumstances, have the opportunity to enroll and succeed in their academic pursuits (NUC, 2011). Equity, on the other hand, focuses on providing the necessary support and resources to ensure that all students have a fair chance to achieve their full potential, acknowledging and addressing existing disparities (NUC, 2011). For tertiary institution students in the Calabar Education Zone, Cross River State, Nigeria, ensuring both access and equity is paramount for their individual success and for the broader societal advancement.

This report specifically examines the potential of personalized learning, powered by AI, to enhance access and equity for this cohort of students across tertiary institutions in the Calabar Education Zone, considering the region's unique context and challenges. The subsequent sections of this report will delve into the definitions and principles of personalized learning, explore the applications of AI in creating tailored educational experiences, analyze the specific access and equity challenges faced by tertiary institution students in the Calabar Education Zone, investigate how AI-driven personalized learning can potentially mitigate these challenges, provide global examples of universities that have successfully implemented such approaches, discuss the potential benefits and drawbacks for tertiary institution students, explore key considerations for successful implementation, and finally, assess the current technological infrastructure at tertiary institutions in the Calabar Education Zone to support these initiatives.

Personalized learning in higher education represents a paradigm shift from traditional, uniform instructional methods to approaches that prioritize the individual learner. At its core, personalized learning is an educational strategy that customizes instruction, learning materials, and the speed of learning to align with the specific needs, interests, and abilities of each student (Education Hub, n.d.). This learner-driven approach places significant emphasis on student agency, encouraging self-directed learning and the strategic use of technology to create customized educational experiences (Education Hub, n.d.). It empowers learners to actively participate in their educational journey, supporting them in achieving their goals through methods that resonate best with their individual learning styles (Tyton Partners, 2015). This contrasts with more traditional, teacher-centered classrooms where educators typically direct instruction to the whole class simultaneously, dictating the content, pace, and method of learning (Tyton Partners, 2015). Instead, in a personalized learning environment, educators collaborate with students to determine the pace and focus of study, often working with smaller groups or individuals to provide targeted support based on their unique needs and assessment results (Tyton Partners, 2015).

The definition of personalized learning often encompasses the idea of instruction that is paced according to learning needs, tailored to learning preferences, and aligned with the specific interests of individual students (ISTE, n.d.). The U.S. Department of Education, in its 2017 National Education Technology Plan, formally defined personalized learning as instruction where the pace of learning and the instructional approach are optimized for the needs of each learner, with learning objectives, instructional approaches, and instructional content potentially varying (U.S. Department of Education, 2017). This concept is not entirely new; historical examples, such as the oral sharing of family and community history, highlight the inherent value of relevant and meaningful learning experiences tailored to the individual (U.S. Department of Education, 2017). Over time, and particularly with advancements in technology, the means of delivering personalized learning have evolved significantly (ISTE, n.d.). It is important to recognize that personalized learning is a broad term that encompasses various related educational concepts, including adaptive learning, which adjusts content based on a learner's performance, and differentiated instruction, which involves modifying teaching methods to suit different learning styles (Wikipedia, n.d.). The various definitions of personalized learning share common themes, such as a student-centered focus, the promotion of student agency, the provision of flexible learning environments, an emphasis on demonstrated mastery of competencies, and a holistic perspective on the learner (U.S. Department of Education, 2017).

Several key principles underpin the effective implementation of personalized learning in higher education. These include enabling student voice and choice in what, how, when, and where they learn, customizing learning experiences to each student's strengths and needs, fostering student agency by empowering them to take ownership of their learning, and ensuring flexibility in instructional delivery (Gates Foundation, n.d.). The Bill & Melinda Gates

Foundation has identified four key attributes of personalized learning: learner profiles, which capture individual student backgrounds and learning styles; personal learning paths, offering varied routes to achieve learning goals; competency-based progression, where students advance based on demonstrated understanding; and flexible learning environments that adapt to diverse needs (Gates Foundation, n.d.). These principles stand in contrast to traditional classrooms where the teacher typically guides the entire class through the same material at the same pace (Tyton Partners, 2015). The International Society for Technology in Education (ISTE) highlights five key elements: flexible, anytime/everywhere learning; a redefined role for the teacher as a guide; authentic project-based learning; student-driven learning pathways; and mastery/competency-based progression (ISTE, n.d.). Data-driven decisions and student reflection on their learning are also crucial components of personalized learning frameworks (Teach For America, n.d.). Ultimately, personalized learning aims to align educational experiences with students' individual interests and goals, fostering deeper engagement and motivation (QS, n.d.).

Various conceptual frameworks exist to guide the understanding and implementation of personalized learning. One such framework is the Core Four Elements of Personalized Learning, which includes flexible content and tools, targeted instruction based on individual needs, data-driven decisions to inform teaching and learning, and student reflection and ownership of their learning (Gates Foundation, n.d.). Another way to conceptualize personalized learning is through a continuum, ranging from teacher-centered lessons that utilize technology to tailor instruction based on performance, to student-centered classrooms where students shape their learning experiences based on their interests and passions (Newsela, n.d.). Recognizing and addressing the diverse learning styles of students, whether visual, auditory, kinesthetic, or reading/writing, is also a fundamental aspect of personalized learning frameworks (Western Governors University, n.d.). These different frameworks suggest that a singular approach to personalized learning may not be universally applicable, and institutions like those in the Calabar Education Zone might need to adopt or adapt a framework that best suits their specific context, resources, and educational objectives.

The Application of Artificial Intelligence to Personalize Learning Experiences for University Students: Current Trends and Potential.

Artificial intelligence is rapidly transforming various sectors, and education is no exception (Forbes, 2023a; Forbes, 2023b). Its capacity to analyze extensive datasets and adapt to individual needs has paved the way for significant advancements in personalized learning approaches within higher education (Forbes, 2023a; Forbes, 2023b). AI enables universities to adapt to the unique requirements of each student in real-time, offering the potential to revolutionize how learning experiences are delivered and received (Deloitte, n.d.). This includes adjusting the difficulty of coursework, identifying specific learning gaps that a student may have, and providing tailored recommendations for content that aligns with their individual learning trajectory (Deloitte, n.d.). Beyond simply adapting to needs, AI can also cater to the specific preferences and interests of students, creating a more engaging and relevant learning environment at scale (IBM, n.d.). By leveraging AI and data analytics, institutions can effectively track student performance, gaining valuable insights that can be used to continuously optimize the overall learning experience (IBM, n.d.). This dynamic adaptation, driven by data analysis, offers a significant advantage over traditional educational methods, allowing for a level of personalization that can be effectively implemented even with large student populations.

AI plays a crucial role in enhancing the feedback and assessment processes within personalized learning. It can provide students with instant and automated feedback on their work, allowing them to understand their strengths and weaknesses more effectively (IBM,
n.d.). Furthermore, AI can assist educators with the often-time-consuming task of grading assignments and assessments, while also identifying specific areas where students may be struggling with the material (IBM, n.d.). The integration of AI-driven assessments and predictive analytics allows institutions to monitor student progress in real-time, enabling them to identify learners who are excelling or who may be falling behind (IBM, n.d.). This proactive approach allows for timely interventions and support to ensure that students stay on track and achieve their academic goals. The ability of AI to enhance the feedback loop provides both students and educators with valuable information that can lead to improved learning outcomes.

The application of AI extends to the creation and delivery of learning content, offering opportunities for enhanced personalization and engagement. AI can generate custom learning materials, such as quizzes, flashcards, and even entire lessons, tailored to a student's specific strengths and weaknesses (PwC, n.d.). Moreover, AI can personalize the way content is delivered to students, adapting to their individual performance, preferences, and progress throughout a course (Microsoft, n.d.). This ensures that students receive the information they need in a format and at a pace that is most conducive to their learning. AI also plays a significant role in creating more interactive learning experiences through the integration of technologies like virtual reality and gamification (Microsoft, n.d.). These immersive and engaging methods can capture students' interest and encourage more active participation in the learning process. By assisting in the creation of diverse and appealing learning materials, AI can make education more accessible and engaging for a broader range of students with varying learning styles and preferences.

Furthermore, AI has the potential to significantly enhance accessibility and promote inclusion within higher education. AI-powered tools can support students with disabilities through features such as text-to-speech and speech-to-text functionalities, making learning materials more accessible (IBM, n.d.). For students who are multilingual learners, AI-driven translation tools can help to break down language barriers and make course content more inclusive (IBM, n.d.). AI can also be utilized to provide customized instruction that caters to the specific needs of neurodiverse learners, ensuring that they can engage with the material in a way that suits their individual requirements (Microsoft, n.d.). The ability of AI to provide these types of adaptations and supports demonstrates a clear pathway for fostering greater equity in access to educational resources for all students, regardless of their background or learning style.

A growing number of AI-powered tools and platforms are being developed and implemented to facilitate personalized learning in higher education. These include adaptive learning platforms, such as Khan Academy, DreamBox Learning, and Smart Sparrow, which use AI algorithms to tailor course content and learning paths to individual students' needs and progress (eCampus News, 2023). Intelligent tutoring systems, like Carnegie Learning's MATHia, provide one-on-one tutoring experiences by simulating human tutors and offering personalized support (Microsoft, n.d.). AI writing assistants, such as Jasper, can help educators create lesson plans and educational content more efficiently (OpenAI, n.d.b). AI-powered study tools, like those offered by Pearson, provide personalized support and feedback to students as they engage with course materials (Pearson, n.d.). Additionally, AI is being integrated into tools for gamification, such as Quizizz and Classcraft, to make learning more engaging (IBM, n.d.). Platforms for collaborative reading, like Perusall, utilize AI to enhance student engagement with reading assignments (OpenAI, n.d.b), and tools for lecture transcription, such as Otter.ai, provide valuable support for note-taking and accessibility (OpenAI, n.d.b). The increasing availability and sophistication of these AI-powered tools and platforms indicate a growing maturity and accessibility of these technologies for use in higher education settings.

Examining the Landscape of Access and Equity Challenges for Tertiary Institution Students in the Calabar Education Zone.

Tertiary institution students in the Calabar Education Zone, Cross River State, Nigeria, like their counterparts in many Nigerian public universities, face a complex array of challenges related to both access to higher education and equity within the educational system. These challenges span systemic policies, infrastructural limitations, socio-economic disparities, and various forms of discrimination.

The Calabar Education Zone is home to several tertiary institutions, including the University of Calabar (UNICAL) (University of Calabar Nigeria, n.d.), the University of Cross River State (UNICROSS) (Times Higher Education, n.d.) (which includes former institutions like The Polytechnic, Calabar, and the College of Education, Akamkpa), Arthur Jarvis University (EduRank, n.d.), and the College of Health Technology, Calabar (Google, n.d.). The Federal Polytechnic, Ugep, is also accessible from Calabar (Cross River University of Technology, n.d.).

Gaining access to university education in Nigeria is a significant hurdle for many qualified candidates. Nigerian universities often operate with limited carrying capacities, meaning they can only admit a fraction of the students who apply each year (NUC, 2011). This intense competition for limited spaces is further complicated by policies such as the quota system and catchment area admissions, which were initially intended to promote equitable access for students from educationally less developed states and those within the university's immediate geographic region (NUC, 2011). However, these policies have been criticized for potentially hindering access for more academically qualified candidates from other regions (NUC, 2011).

Furthermore, the cost of university education, including tuition fees, accommodation, and other expenses, can be unaffordable for many students, particularly those from low-income backgrounds, creating a significant barrier to access (NUC, 2011). In certain regions of Nigeria, armed conflicts and insecurity can also severely disrupt access to education, forcing students to flee their homes and abandon their studies (NUC, 2011). Beyond these systemic and socio-economic factors, infrastructural problems within universities also contribute to the challenges of access. Inadequate lecture halls often lead to overcrowding, making it difficult for students to learn effectively (JAMB, 2021). Similarly, ill-equipped libraries and laboratories limit students' ability to engage in research and practical learning (JAMB, 2021). A particularly pervasive issue in Nigerian public universities is the unstable power supply and poor internet services, which significantly hinder students' access to online resources and e-learning opportunities (Okoro et al., 2023). For specific vulnerable populations, such as internally displaced persons, accessing higher education presents even greater difficulties (UNHCR, n.d.). In the context of Cross River State, the recent approval of a second state-owned university, the Cross River State University of Education and Entrepreneurship (Premium Times, 2024), suggests an ongoing effort to expand access to higher education in the region, which historically has relied primarily on the University of Calabar as the main public institution (Wikipedia, n.d.b). Overall, access to higher education at tertiary institutions in the Calabar Education Zone is a multifaceted challenge shaped by a combination of national policies, institutional limitations, and socio-economic realities.

In addition to the challenges of gaining access, tertiary institution students in the Calabar Education Zone also face issues related to equity within their educational experiences. Gender inequality remains a significant concern in Nigerian higher education, with female students often facing various forms of discrimination, including sexual harassment and pressure for grades (NUC, 2011). Disparities in educational opportunities and outcomes also exist based on students' socio-economic backgrounds, with poverty often limiting access to resources and support (JAMB, 2021). The selection methods used for university admissions have also been criticized for potential biases that may disadvantage certain groups of students (NUC, 2011). Furthermore, the current educational system may not adequately address the diverse learning needs and individual differences among students, potentially leading to inequitable outcomes for those with different aptitudes and interests (NUC, 2011). Students with disabilities often face significant barriers to accessing and participating fully in university education due to a lack of adequate infrastructure and support services (UNESCO, 2016). There are also concerns about the overall quality of education and the potential for admission policies to sometimes prioritize factors other than academic merit, potentially leading to a decline in standards (ASUU, 2022). The issue of examination malpractices further undermines the principles of equity by creating an uneven playing field for students (JAMB, 2022). Addressing these multifaceted equity challenges is crucial for ensuring that all tertiary institution students in the Calabar Education Zone have a fair and just opportunity to succeed in their academic endeavors.

The Potential of AI-Powered Personalized Learning to Address Access and Equity Challenges in the Calabar Education Zone.

The integration of AI-powered personalized learning holds considerable potential for addressing the multifaceted access and equity challenges faced by tertiary institution students in the Calabar Education Zone. By leveraging the capabilities of AI to tailor educational experiences to individual needs, institutions in the zone can explore innovative solutions to overcome existing barriers and foster a more inclusive and equitable learning environment.

AI-driven adaptive learning platforms can offer flexible learning pathways that allow students to progress through course material at their own pace, which can be particularly beneficial for students who may have varying levels of prior preparation or who learn at different speeds (IBM, n.d.). This flexibility can help students overcome challenges related to a rigid, one-size-fits-all curriculum and allow them to focus on areas where they need more support. Furthermore, online and blended learning models, facilitated by AI, can significantly expand access to higher education for students who may face geographical limitations, financial constraints that make on-campus attendance difficult, or other personal circumstances that hinder traditional enrollment (IBM, n.d.). AI-powered tutoring systems can provide students with on-demand academic support outside of traditional classroom hours, potentially mitigating the impact of inadequate staffing or overcrowded classrooms by offering personalized guidance and explanations whenever needed (IBM, n.d.). Additionally, AI can automate various administrative tasks for educators and university staff, potentially freeing up valuable time and resources that can be redirected towards improving essential infrastructure, enhancing student support services, or developing more effective learning materials (OpenAI, n.d.).

In addressing equity challenges, AI-powered personalized learning can adapt both the content and the pace of learning to cater to the diverse learning styles and individual needs of students, thereby directly tackling the issue of a standardized curriculum that may not suit everyone (IBM, n.d.). AI tools can significantly enhance accessibility for students with disabilities by providing features such as text-to-speech and speech-to-text, allowing them to engage with learning materials in formats that are more suitable for their needs (IBM, n.d.). Moreover, AI can provide targeted support and interventions for students who are identified as falling behind academically, potentially helping to close disparities in academic performance and ensure that all students have the opportunity to succeed (IBM, n.d.). While caution is necessary, AI also has the potential to identify and mitigate biases that may exist within educational materials and assessments, contributing to a more equitable evaluation of student learning (PwC, n.d.). Furthermore, AI can facilitate the creation of more inclusive learning environments that take into account diverse cultural contexts and individual learning preferences, promoting a sense of belonging and ensuring that all students feel supported in their educational journey (IBM, n.d.). By offering these tailored and adaptive approaches, AI-powered personalized learning presents a promising pathway for fostering greater equity and inclusivity across tertiary institutions in the Calabar Education Zone.

Global Perspectives: Case Studies of Universities Implementing Personalized Learning and AI to Improve Educational Access and Equity.

Across the globe, numerous universities are actively exploring and implementing AI-powered personalized learning initiatives with a growing emphasis on enhancing student outcomes and addressing critical equity concerns. These examples offer valuable insights and potential models for tertiary institutions in the Calabar Education Zone to consider as they embark on their own journey towards leveraging these transformative technologies.

Arizona State University, for instance, utilizes adaptive math courses that employ real-time analytics through the ALEKS system to pinpoint students' knowledge gaps, providing targeted exercises to keep learners engaged and motivated (eCampus News, 2023). Georgia Tech has implemented an AI teaching assistant named Jill Watson, which operates 24/7 to answer student queries, freeing up professors to focus on more in-depth mentoring and support (eCampus News, 2023). Southern New Hampshire University offers competency-based programs that allow students to progress based on their mastery of skills, providing flexibility for adult learners balancing work and family responsibilities (eCampus News, 2023). The University of Pittsburgh School of Law has successfully used AI in its admissions process to increase the diversity of its incoming class, demonstrating the potential of AI to promote equity in access (IBM, n.d.b). Recognizing the challenges of the AI divide, the University of Central Oklahoma is actively working to help students navigate the responsible and effective use of AI tools (Inside Higher Ed, 2023a). Montclair State University is considering strategies to ensure equitable access to premium AI tools for all its students, including the possibility of incorporating the cost into tuition fees (Inside Higher Ed, 2023a). College Unbound has designed its bachelor's degree program around a personalized, interest- and project-based curriculum, highlighting an alternative approach to traditional learning (Inside Higher Ed, 2023a). Ohio University is actively exploring the creation of personalized learning experiences using AI, including allowing students to use AI to generate quizzes related to their topics of study (Ohio University, 2023). The University of Notre Dame conducted a workshop specifically focused on how AI can be leveraged to promote inclusive education for students from diverse backgrounds, emphasizing the potential of AI to foster equity in the classroom (University of Notre Dame, 2023). Similarly, experts at the University of Maryland are researching how to harness the power of AI to foster equity at all levels of education (University of Maryland, 2023). Stanford University has developed a model that combines synchronous and asynchronous learning with AI to simultaneously democratize and humanize

education (Stanford Online, n.d.). The University of Alicante in Spain has developed an AI-powered application called "Help Me See" to improve accessibility and learning experiences for visually impaired students, showcasing a direct application of AI to address equity (Universitat d'Alacant, n.d.). The University of Sydney implemented an AI-driven platform called "Smart Sparrow," which allows educators to create adaptive learning pathways within their courses, leading to increased student engagement and improved academic performance (Universitat d'Alacant, n.d.). Other institutions like the University of Edinburgh, the National University of Singapore, and MIT are also actively involved in researching and implementing various AI initiatives in education (Universitat d'Alacant, n.d.). Mohammed VI Polytechnic University has developed a mobile-optimized AI-driven personalized learning platform, demonstrating the potential of AI to enhance learning through mobile devices (Mohammed VI Polytechnic University, n.d.). Furthermore, the Association of Public & Land-grant Universities (APLU) in partnership with Every Learner Everywhere has produced a series of case studies on adaptive learning initiatives at various universities, including
Cleveland State University, Florida International University, and others, with the specific goal of improving student success outcomes and eliminating equity gaps for minoritized, poverty-affected, and first-generation students (APLU & Every Learner Everywhere, n.d.). These diverse examples underscore the widespread recognition of AI's potential to transform higher education in ways that enhance both personalization and equity.

While the inherent adaptability of personalized learning through AI offers a pathway to improved equity, several institutions are specifically focusing on utilizing AI tools to address existing disparities and promote inclusivity. The University of Alicante's work with visually impaired students is a prime example of AI directly improving accessibility (Universitat d'Alacant, n.d.). The APLU case studies highlight initiatives specifically designed to close equity gaps for disadvantaged student populations through the use of adaptive learning technologies (APLU & Every Learner Everywhere, n.d.). Moreover, universities like Montclair State and Maryland are actively considering and researching strategies to ensure that all students, regardless of their socio-economic background, have equitable access to AI tools and the necessary training to utilize them effectively (Inside Higher Ed, 2023a). The University of Pittsburgh School of Law's successful use of AI in admissions to increase diversity demonstrates a targeted application of AI to enhance equity in access to educational opportunities (IBM, n.d.b). These focused efforts highlight a growing awareness within higher education of the importance of intentionally leveraging AI not just for personalization, but also as a tool to dismantle existing barriers and create a more equitable educational landscape for all students.

Analyzing the Potential Benefits and Drawbacks of Using Personalized Learning and AI for Tertiary Institution Students.

The integration of personalized learning and AI into the educational experiences of tertiary institution students in the Calabar Education Zone presents a spectrum of potential benefits and drawbacks that warrant careful consideration. These factors can significantly impact the students' learning outcomes, their preparation for future endeavors, and the overall quality of their educational experience.

Among the potential benefits, enhanced engagement and motivation stand out as key advantages. By tailoring content and learning paths to individual interests and needs, students are more likely to feel invested in their education, leading to increased motivation and a deeper engagement with the subject matter (University of Southern Queensland, n.d.). This personalized approach can also lead to improved academic outcomes and a greater mastery of learning objectives, as students can focus on areas where they need the most support and learn at a pace that suits them best (University of Southern Queensland, n.d.). The increased flexibility in learning pace and time offered by personalized learning and AI can be particularly beneficial for students who may be juggling coursework with other commitments such as part-time jobs or family responsibilities (University of Southern Queensland, n.d.). Furthermore, this approach can foster the development of essential life skills, such as self-directed learning, critical thinking, and problem-solving abilities, which are crucial for success beyond graduation (QS, n.d.). By allowing students to cultivate their unique skill sets and enhance self-awareness, personalized learning can also contribute to better preparation for future careers (University of Southern Queensland, n.d.). For students with diverse learning needs, including those with disabilities, personalized learning and AI can offer greater accessibility and inclusivity through tailored content and assistive technologies (QS, n.d.). The ability of AI to provide timely feedback and facilitate early intervention can also help students address any remaining learning gaps before they complete their studies (IBM, n.d.). Finally, personalized learning experiences often involve deeper engagement with learning materials through interactive tools and adaptive content, potentially leading to a more enriching and effective educational journey (University of Southern Queensland, n.d.). These benefits related to skill development, career readiness, and addressing academic needs are particularly significant for tertiary institution students.

However, the implementation of personalized learning and AI for tertiary institution students also presents several potential drawbacks that must be carefully considered. Questions arise regarding the accuracy and reliability of assessments that are heavily reliant on AI-driven evaluations (University of Southern Queensland, n.d.). Ensuring the scalability of personalized learning while maintaining the quality of education for a large cohort of students can also pose a significant challenge (University of Southern Queensland, n.d.). Educators may face an increased workload in the initial stages of designing and implementing personalized learning experiences, requiring time and effort to adapt their teaching practices and develop new materials (EdTech Magazine, 2023). The collection and analysis of student data, which is central to AI-powered personalization, raises concerns about potential data breaches and the privacy of sensitive information (EdTech Magazine, 2023). There is also the risk of bias being embedded within AI algorithms, which could inadvertently lead to inequitable outcomes for certain groups of students (PwC, n.d.). Over-reliance on technology might also lead to a reduction in crucial human interaction and the social-emotional aspects of learning that are vital for holistic development (The Conversation, 2023). The initial and ongoing costs associated with implementing the necessary technology and infrastructure for AI-driven personalized learning can be substantial (The Conversation, 2023). Furthermore, there is a concern that students might become overly dependent on AI tools, potentially undermining the development of their own critical thinking and problem-solving skills (Inside Higher Ed, 2023b). The availability of AI writing tools also raises concerns about academic misconduct and plagiarism, requiring institutions to develop clear policies and guidelines (OpenAI, n.d.a). Finally, the existing digital divide, where some students have unequal access to technology and reliable internet, could be exacerbated if personalized learning initiatives are heavily dependent on these resources (Inside Higher Ed, 2023a). Addressing these potential drawbacks through careful planning, robust policies, and adequate resource allocation will be essential for the successful and equitable implementation of personalized learning and AI for tertiary institution students in the Calabar Education Zone.

Key Considerations for the Successful Implementation of Personalized Learning and AI Initiatives within the Context of Tertiary Institutions in the Calabar Education Zone

The successful integration of personalized learning and AI initiatives at tertiary institutions in the Calabar Education Zone will require a strategic and thoughtful approach that takes into account the region's unique context and challenges. Several key considerations must be addressed to ensure that these initiatives are effective, equitable, and sustainable. A primary consideration is addressing the existing infrastructure limitations, particularly concerning internet connectivity and access for students (Okoro et al., 2023). Given the reported challenges with internet services in Nigerian universities, tertiary institutions in the Calabar Education Zone will need to prioritize investments in upgrading their ICT infrastructure to provide reliable and sufficient internet access across campus and potentially explore solutions for students who may have limited access off-campus. This includes investing in the necessay hardware and software to support AI-driven platforms and ensuring that these resources are readily available to both students and faculty (EdTech Magazine, 2023). Given the prevalence of mobile devices among students, exploring mobile-first personalized learning solutions could also be a strategic approach to enhance accessibility (ISTE, n.d.).

Faculty development and training are equally critical for successful implementation. Educators will require adequate training and ongoing professional development opportunities to effectively utilize AI tools and implement personalized learning strategies in their teaching practices (EdTech Magazine, 2023). This includes supporting them in redefining their roles from traditional lecturers to facilitators and guides who can effectively mentor students through personalized learning pathways (ISTE, n.d.). Addressing potential resistance to change among faculty and fostering a culture of innovation and experimentation will also be essential (WCET, 2017).

Ethical considerations and data privacy must be at the forefront of any AI implementation. Institutions need to establish clear guidelines and policies for the ethical use of AI in education, ensuring transparency and accountability (Forbes, 2023b). Implementing robust data protection measures to safeguard the privacy of student information is paramount (University of Southern Queensland, n.d.). Furthermore, proactive steps must be taken to identify and mitigate potential biases within AI algorithms to ensure fairness and equity in learning experiences and outcomes for all students (PwC, n.d.).

The curriculum design and assessment strategies of tertiary institutions will likely need to be reviewed and adapted to fully leverage the benefits of personalized learning and AI. This may involve revising the curriculum to incorporate more flexible and adaptive learning approaches and exploring innovative assessment methods that go beyond traditional examinations to focus on competency-based progression and the demonstration of actual learning (University of Southern Queensland, n.d.). Ensuring that personalized learning initiatives remain aligned with established learning objectives and academic standards is also crucial (Tyton Partners, 2015).

Finally, successful implementation will necessitate active engagement and open communication with all stakeholders within the university community, including students, faculty, administrators, and potentially even external partners (PwC, n.d.). Clearly communicating the benefits and goals of personalized learning and AI initiatives will help to build understanding and support (Teach For America, n.d.). Establishing mechanisms for gathering feedback from students and faculty and iteratively improving the initiatives based on this feedback will be essential for long-term success (University of Southern Queensland, n.d.). By carefully considering these key factors, tertiary institutions in the Calabar Education Zone can lay a strong foundation for the successful and equitable integration of personalized learning and AI to enhance the educational experiences of their students.

Assessing the Current Technological Infrastructure and Resources at Tertiary Institutions in the Calabar Education Zone to Support AI-Driven Personalized Learning

An assessment of the current technological infrastructure and resources at tertiary institutions in the Calabar Education Zone is crucial to understanding their readiness to support AI-driven personalized learning initiatives. Key institutions in this zone include the University of Calabar (UNICAL) (University of Calabar Nigeria, n.d.), the University of Cross River State (UNICROSS) (Times Higher Education, n.d.), Arthur Jarvis University (EduRank, n.d.), the College of Health Technology, Calabar (Google, n.d.), and the Federal Polytechnic, Ugep (Cross River University of Technology, n.d.). Taking the University of Calabar as a representative example, the institution has an established Information and Communications Technology (ICT) Directorate responsible for developing, maintaining, and adapting ICT infrastructure, products, and services for the university community (University of Calabar, n.d.). This directorate manages various aspects of the university's technological resources, including providing internet services, creating email accounts for staff and students, maintaining the university website, developing portals for different academic units, and managing staff and student databases (University of

Calabar, n.d.). The university also has several computer resource rooms, such as the E-Library and computer laboratories within specific departments and faculties (University of Calabar, n.d.). However, research suggests that the utilization of ICT by students, particularly in the Faculty of Allied Medical Sciences, may be low due to the inadequacy of ICT facilities and a lack of sufficient training and competence (Akpan & Akpan, 2019). While ICT is used, it is often primarily for social networking and recreation rather than academic purposes (Akpan & Akpan, 2019). This indicates a potential gap between the availability of basic infrastructure and its effective application in academic learning across institutions in the zone.

Regarding e-learning facilities, research indicates that while some facilities like computers are available and utilized to a high extent in teaching and learning, others, such as video conferencing tools, are not as readily available (Umar & Musa, 2021). Platforms like Google Classroom and other online tools are being used to some extent (Umar & Musa, 2021). However, a significant challenge that affects the effective use of e-learning facilities is the unreliable electricity supply (Ajadi et al., 2020). The University of Calabar does have an Open and Distance Learning Centre (ODLC), which offers online degree programs, suggesting some existing capacity for virtual learning within the zone (University of Calabar ODLC, n.d.). However, the overall adequacy and functionality of e-learning resources and the underlying infrastructure (like consistent internet access and power) may still pose challenges for the widespread adoption of advanced AI-powered personalized learning approaches across tertiary institutions in the Calabar Education Zone.

Looking at the broader context of digital infrastructure in Nigerian public universities reveals several recurring challenges that likely mirror the situation at institutions in the Calabar Education Zone. These include inconsistent and slow internet connectivity, inadequate computing resources, and varying levels of integration of e-learning platforms (Adeleke et al., 2021). Poor funding, a lack of adequate infrastructure, and insufficient digital literacy among both educators and students are identified as key issues hindering the comprehensive digitalization of higher education in Nigeria (Adedamola & Adebayo, 2022). The COVID-19 pandemic further exposed these digital inadequacies, highlighting the urgent need for improvements (Oluwasegun & Ayobami, 2021). While some universities in Nigeria have made strides in digitizing administrative processes and adopting online learning platforms (Adeleke et al., 2023), many still face significant obstacles related to infrastructure and access to technology (Adeleke et al., 2023). The degree of use of digital infrastructures in Nigerian universities is generally low, and this has been shown to impact students' learning effectiveness (Owoseni & Amode, 2019). Therefore, while tertiary institutions in the Calabar Education Zone have some foundational ICT and e-learning resources, significant upgrades and strategic investments will likely be necessary to create a robust technological ecosystem capable of supporting sophisticated AI-driven personalized learning initiatives across all disciplines and for all students.

Conclusion and Recommendations

A Strategic Roadmap for Leveraging Personalized Learning and AI to Foster Access and Equity in the Calabar Education Zone.

The analysis presented in this report underscores the significant potential of personalized learning, enhanced by artificial intelligence, to address the pressing challenges of access and equity for tertiary institution students in the Calabar Education Zone. By tailoring educational experiences to individual needs, AI can help to overcome barriers related to inflexible curricula, limited support, and disparities in learning resources. However, the successful implementation of such initiatives requires a comprehensive and strategic approach that acknowledges the region's unique context and the broader landscape of higher education in Nigeria.

Based on the findings of this report, the following specific and actionable recommendations are proposed for tertiary institutions in the Calabar Education Zone and relevant educational stakeholders:

Develop a Strategic Plan: Institutions should formulate a clear and comprehensive strategic plan for the adoption of personalized learning and AI, aligning it with their overall mission, goals, and the specific needs of their student population. This plan should outline clear objectives, timelines, and key performance indicators for the successful integration of these approaches.

Prioritize Infrastructure Investment: A critical step is to prioritize substantial investments in upgrading the ICT infrastructure across institutions. This includes significantly improving internet connectivity across all campus areas and exploring solutions to ensure reliable internet access for students off-campus. Investing in the necessary hardware and software to support AI-driven learning platforms and providing adequate technical support for both students and faculty are also essential.

Establish a Faculty Development Program: A comprehensive and ongoing faculty development program should be established to equip educators with the knowledge and skills necessary to effectively design and implement personalized learning experiences using AI tools. This program should focus on pedagogical shifts required for student-centered learning, the effective use of specific AI applications relevant to their disciplines, and strategies for creating inclusive and accessible learning environments.

Develop Ethical Guidelines and Data Privacy Policies: Institutions must proactively develop clear ethical guidelines and robust data privacy policies specifically for the use of AI in education. These policies should address issues such as data security, student consent, algorithmic bias, and academic integrity, ensuring responsible and equitable implementation of AI technologies.

Review and Adapt Curriculum and Assessment: The existing curriculum and assessment strategies should be reviewed and adapted to align with the principles of personalized learning and to fully leverage the capabilities of AI. This may involve incorporating more flexible learning pathways, integrating AI tools into coursework, and exploring alternative assessment methods that focus on demonstrating competency and mastery of learning outcomes.

Foster Stakeholder Engagement and Communication: Throughout the planning and implementation process, it is crucial to actively engage all stakeholders, including students, faculty, administrative staff, and potentially alumni and community partners. Open and transparent communication about the goals, benefits, and potential challenges of personalized learning and AI initiatives will help to build buy-in and ensure a collaborative approach.

Explore Partnerships and Collaborations: Tertiary institutions in the Calabar Education Zone should explore potential partnerships and collaborations with other universities, both within Nigeria and internationally, as well as with technology providers specializing in AI and educational solutions. These collaborations can provide access to best practices, shared resources, and valuable expertise in implementing personalized learning and AI.

Conduct Pilot Programs and Iterative Evaluation: Before a full-scale implementation, institutions should consider conducting pilot programs in specific departments or with a subset of students to test the effectiveness of different personalized learning and AI approaches. The results of these pilot programs should be carefully evaluated to identify what works best within the local context and to inform iterative improvements to the initiatives.

Consider Establishing a Center for Innovation in Teaching and Learning: Establishing a dedicated center for innovation in teaching and learning could provide a central hub for supporting faculty in exploring and implementing new pedagogical approaches, including personalized learning and the use of AI. This center could offer resources, training, and ongoing support to drive innovation in educational practices across the institutions.

Address the Digital Divide: Recognizing the potential for a digital divide among students, institutions should develop strategies to ensure equitable access to the necessary technology and resources for all students to participate effectively in AI-driven personalized learning initiatives. This may include providing access to devices, offering affordable internet options, or creating on-campus facilities with adequate resources.

By embracing these recommendations, tertiary institutions in the Calabar Education Zone can strategically leverage the power of personalized learning and artificial intelligence to create a more accessible, equitable, and ultimately more effective educational experience for their students, preparing them for success in their future academic and professional pursuits. The transformative potential of these approaches holds the key to unlocking the full potential of every tertiary institution student in the Calabar Education Zone.

Table 1: Summary of Access and Equity Challenges for Tertiary Institutions in the Calabar Education Zone (Section 4)

Challenge Category	Specific Challenge
Access	Limited carrying capacity of universities (NUC, 2011)
	Impact of quota system and catchment area policies (NUC, 2011)
	Unaffordable costs of university education (NUC, 2011)
	Impact of armed conflicts and insecurity on education (NUC, 2011)
	Inadequate lecture halls, libraries, and laboratories (JAMB, 2021)
	Unstable power supply and poor internet services (Okoro et al., 2023)
	Challenges faced by internally displaced persons (IDPs) (UNHCR, n.d.)
	Limited number of public universities in Cross River State (Premium Times, 2024; Wikipedia, n.d.b)
Equity	Gender inequality and discrimination (incl. harassment) (NUC, 2011)
	Disparities based on socio-economic background and poverty (JAMB, 2021)
	Potential biases in university selection methods (NUC, 2011)
	Inadequate addressing of individual student differences (NUC, 2011)
	Challenges faced by students with disabilities (UNESCO, 2016)

		Concerns about quality of education due to admission policies (ASUU, 2022) Examination malpractices (JAMB, 2022)

Table 2: Potential AI Applications for Personalized Learning and Addressing Access & Equity (Section 5)

AI Application	How it Addresses Access Challenges	How it Addresses Equity Challenges
Adaptive Learning Platforms	Provides flexible learning pathways, allowing self-paced learning (IBM, n.d.)	Caters to diverse learning styles and needs, adjusts pace for individual learners (IBM, n.d.)
Online and Blended Learning Models	Expands access for students facing geographical or financial barriers (IBM, n.d.)	Offers flexibility for diverse lifestyles and commitments (IBM, n.d.)
AI-Powered Tutoring Systems	Provides on-demand support, mitigating impact of inadequate staffing or overcrowded classrooms (IBM, n.d.)	Offers personalized guidance and explanations, addressing individual learning gaps (IBM, n.d.)
AI for Content Creation and Delivery	Generates custom learning materials (PwC, n.d.)	Personalizes content delivery to individual performance, preferences, and progress (Microsoft, n.d.)
AI for Interactive Learning	Creates interactive experiences through VR and gamification (Microsoft, n.d.)	Makes education more engaging for diverse learning styles (Microsoft, n.d.)
AI for Accessibility & Inclusion	Supports students with disabilities via text-to-speech, speech-to-text (IBM, n.d.)	Breaks down language barriers for multilingual learners; customized instruction for neurodiverse learners (IBM, n.d.; Microsoft, n.d.)

Automation of Admin Tasks	Frees up resources for infrastructure and student support (OpenAI, n.d.a.)	Allows educators to focus on individualized student needs (OpenAI, n.d.a.)
AI in Assessments & Feedback	Provides instant feedback, identifies learning gaps (IBM, n.d.)	Monitors student progress in real-time, identifies students falling behind for timely interventions (IBM, n.d.)

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EFFECT OF KHAN ACADEMY LEARNING PLATFORM ON JUNIOR SECONDARY SCHOOL STUDENTS' ACADEMIC PERFORMANCE IN MATHEMATICS IN KWARA STATE

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Abstract

Learning platforms are increasingly vital in modern education, fostering student-driven approaches, yet persistent challenges like unsatisfactory mathematics performance among junior secondary students highlight the need for effective interventions. This study investigated the impact of the Khan Academy Learning Platform on the academic performance of junior secondary school students in Mathematics in Kwara State, Nigeria. Specific objectives included examining pre-test and post-test performance differences and assessing performance in both public and private school settings. Employing a quasiexperimental one-group pre-test, post-test design, the research involved Junior Secondary School three (JSS) students from one public and one private school in Ilorin, Kwara State. Participants engaged with Khan Academy's instructional videos, exercises, and quizzes, with academic performance measured by a Mathematics Performance Test (MPT) administered before and after the intervention. Data analysis utilized percentages for research questions and ANCOVA for hypotheses at 0.05 level of significance. Findings revealed moderate academic improvement for students using the Khan Academy Learning Platform across Kwara State, with average performance observed in public schools and excellent performance in private schools. The study concludes that digital learning platforms such as Khan Academy effectively supplement traditional teaching, particularly in resource constrained environments. It is recommended that educators strategically integrate Khan Academy, ensuring equitable focus across genders. Public schools require enhanced digital resources, while private schools should maintain their effective utilization. Educational planners and policymakers are urged to guarantee equal access to these platforms for all schools, thereby enhancing students' learning experiences.

Keywords: Khan Academy, Learning Platforms, Mathematics & Students Performance

Introduction

Education is widely recognized as the foundation for personal development and societal progress, equipping individuals with the skills, knowledge, and values required to navigate life and make meaningful contributions to their communities. The significance of education extends beyond acquiring academic knowledge; it plays a pivotal role in shaping individuals’ character, enhancing social responsibility, and preparing them to address challenges in the broader society. Over the centuries, education has undergone significant evolution, adapting to the ever-changing needs of society, technological advancements, and economic development. In its earlier forms, education was primarily teacher-centered, often involving rote memorization and a limited range of instructional resources. However, as society has progressed, education has become more diverse, inclusive, and interactive, driven largely by the rise of technology.

Information and Communication Technology (ICT) has played a pivotal role in reshaping education, offering new tools and opportunities for both teaching and learning (Selwyn, 2022). The integration of ICT into education has fundamentally changed the way learning is delivered worldwide. Initially, educational technology in classrooms consisted of simple tools such as projectors or overhead transparencies. However, today’s classrooms are equipped with a variety of digital resources, including online learning environments, virtual classrooms, video conferencing, and complex digital platforms. These technologies enable teachers to offer engaging, multimedia-rich content and foster a more interactive and student-driven learning experience. Furthermore, ICT allows students to access educational materials anytime and from anywhere, helping to bridge the gap caused by geographical and socio-economic limitations (UNESCO, 2022). More importantly, ICT facilitates personalized learning, allowing students to progress at their own pace and revisit topics they find challenging. This individualized approach has been shown to enhance student engagement and motivation, leading to improved academic performance, especially in subjects that students traditionally find difficult, such as mathematics (Clark and Mayer, 202). As technology continues to evolve, the development of digital platforms has further transformed the educational landscape. Digital platforms are online systems or applications designed to facilitate learning by offering interactive content, assessments, and communication tools. These platforms make learning more flexible and accessible, allowing students to learn at their own pace, reinforce what they have learned in class, and foster self-directed learning. The rise of these platforms has democratized education, providing quality educational resources to students in remote or underserved areas who might otherwise have limited access to formal schooling (Mayer, 2021). Platforms such as Khan Academy, Coursera, and edX have made significant strides in this direction, offering free or affordable educational materials to learners around the world. These platforms embody a shift toward more inclusive, accessible, and flexible education, where students can tailor their learning experiences to their individual needs (Hodges et al., 2021).

Khan Academy, one of the most widely recognized digital learning platforms, has had a profound impact on education, particularly in the field of mathematics. Founded in 2008 by Salman Khan, the platform began as a series of simple YouTube videos aimed at helping his cousins understand basic math concepts. Its rapid success led to the creation of a full-fledged educational platform that now offers a wide range of subjects, including math, science, economics, history, and more. Khan Academy's mission is to provide a free, world-class education to anyone, anywhere, and it has reached millions of students in over 190 countries, with content available in multiple languages (Khan, 2021). The platform has become an essential tool for students, especially those in developing countries or in communities with limited access to traditional education. What makes Khan Academy so successful is its user-friendly design and educational approach, which focuses on breaking down complex concepts into bite-sized, easy-to-understand segments. The platform offers short video lessons that explain mathematical principles step by step, making it easier for students to grasp challenging concepts. These videos are complemented by practice exercises that help students reinforce what they've learned, providing immediate feedback to ensure they understand the material. Khan Academy's personalized learning dashboard is another standout feature, allowing students to track their progress, set learning goals, and receive customized recommendations based on their performance. This feature is particularly helpful for students in junior secondary schools, who are starting to engage with more advanced mathematical concepts. By allowing students to learn at their own pace, Khan Academy fosters a more individualized learning experience, helping them build confidence and fill any gaps in their understanding (Lindstrom et al., 2022).

Mathematics, a subject that many students find daunting, is an area where Khan Academy has had a particularly significant impact. Traditional methods of teaching math can often leave students feeling frustrated, especially when they struggle to understand abstract concepts. Khan Academy breaks down difficult topics into manageable lessons and provides interactive practice exercises, making mathematics more accessible. Visual aids such as diagrams and animations further enhance students' understanding by providing a tangible representation of abstract ideas. This innovative approach not only simplifies learning but also promotes a deeper understanding of mathematical principles, which can lead to improved academic performance and greater self-assurance in tackling mathematical challenges (Koedinger et al., 2020). The integration of digital platforms like Khan Academy into the educational system represents a transformative opportunity for improving students' academic performance, especially in subjects like mathematics. In Kwara State, the use of Khan Academy could significantly enhance students' understanding of mathematical concepts, improve their academic performance, and foster a greater enthusiasm for learning.

Statement of the Problem

Mathematics is crucial for students' academic and career success, yet junior secondary students in Kwara State consistently underperform due to difficulties with core concepts, problem-solving, and application, leading to frustration and disinterest. This persistent issue stems from challenges in conventional teaching methods, such as overcrowded classrooms, limited resources, and inadequate individualized instruction, compounded by factors like limited access to textbooks and large class sizes. However, the emergence of digital learning tools like Khan Academy offers a promising solution by providing personalized, self-paced learning experiences through videos and practice exercises. Despite its global success, there is a notable lack of research on Khan Academy's effectiveness specifically within Nigerian junior secondary schools in Kwara State, prompting this study to investigate its potential to enhance mathematical understanding, improve grades, and boost student confidence in this context.

Purpose of Study

The main purpose of this study was to examine the effect of Khan Academy Platform on the performances of junior secondary school students in Mathematics in Kwara State in private and public schools.

Research Questions

The following research questions were answered in this study

1. What is the effect of Khan Academy Platform on the performances of junior secondary school students in Mathematics in private and public schools?

Concept of ICT in Education

Information and Communication Technology (ICT) refers to a broad range of technologies used to handle telecommunications, broadcast Media, intelligent building management systems, audio-visual processing and transmission systems, intelligent transportation systems, and network-based control and monitoring functions (Alhassan & Bello, 2020). According to Oduro et al. (2019), ICT encompasses technologies like computers, internet services, software applications, and digital devices that facilitate the exchange, storage, and retrieval of information. ICT is not only about using technology for communication but also for enhancing various sectors, including education, healthcare, and business. It provides the tools for improving access to information, creating virtual spaces for interaction, and enabling collaboration among individuals and institutions (Ngwu, 2021). Furthermore, it fosters the development of critical thinking and problem-solving skills through technological innovations in diverse fields, making it a key asset in modern educational environments.

In Nigeria, the integration of ICT in education is guided by the National Policy on ICT in Education. This policy advocates for the adoption of digital platforms to improve instructional delivery and student performance, especially in science and mathematics subjects (Yusuf et al., 2022). Despite these policy efforts, challenges such as inadequate digital infrastructure, poor internet connectivity, and low digital literacy among educators remain significant barriers to full-scale ICT adoption (Chigona, 2020). It encompasses diverse communication tools and resources that enable people to connect and interact seamlessly regardless of time and geographical barriers. These technologies include computers, the internet, broadcasting technologies (radio and television), and telecommunication systems such as mobile networks. ICT has transformed the way individuals and organizations access, process, and share information, playing a crucial role in education, business, healthcare, governance, and social interactions.

Concept of Digital Platforms for Teaching and Learning Mathematics

Digital platforms are technology-based frameworks or systems that facilitate the creation, exchange, delivery, and management of information, products, or services through digital means. In a general sense, digital platforms serve as virtual environments where users – whether individuals, organizations, or machines – can interact, collaborate, and perform various tasks using the internet or digital networks. A digital learning platform refers to a technology-based system or application that facilitates instruction, assessment, collaboration, and communication in an online or blended learning environment. These platforms support both synchronous and asynchronous modes of learning and often include tools for content delivery, practice exercises, feedback, and progress tracking.

Digital platforms have emerged as critical tools in enhancing mathematics instruction. These platforms include structured learning environments such as Khan Academy, Google Classroom, GeoGebra, MyMathLab, and Desmos. They offer instructional videos, interactive exercises, problem-solving simulations, and real-time feedback mechanisms. Such features make learning mathematics more engaging, especially for students who may struggle with traditional instructional methods. For example, Khan Academy delivers topic-based video tutorials and adaptive learning paths that allow learners to progress at their own pace, revisit challenging topics, and monitor their own learning progress (Schindler et al., 2021).

These digital tools cater to diverse learning preferences by providing content in multiple formats – visual, auditory, and kinesthetic. Platforms like GeoGebra and Desmos allow students to explore mathematical relationships through graphs and interactive simulations, which enhance conceptual understanding. Others, such as Prodigy Math and Mathletics, gamify the learning experience, increasing motivation through points, levels, and badges (Adegbija&Fakomogbon, 2021). By making abstract concepts more tangible, digital platforms help reduce math anxiety and foster a positive learning experience. However, the benefits of digital platforms are tempered by significant challenges in the Nigerian context. Many students, particularly in rural areas, lack access to devices and stable internet connections (Afolabi & Ojo, 2021). Furthermore, digital literacy among teachers remains limited, often resulting in underutilization of available technology. Financial constraints also prevent schools from investing in paid learning platforms or the infrastructure needed to support digital education (Eze & Nwosu, 2023). Despite these limitations, the integration of digital tools into the mathematics curriculum remains a promising strategy. Mathematics at the junior secondary level plays a foundational role in students' cognitive and analytical development. Topics such as number and numeration, algebra, geometry, and data handling are designed to build problem-solving skills, logical reasoning, and numerical fluency (Ajayi & Olusola, 2020). Yet many students continue to struggle due to a poor foundation, negative attitudes, and a lack of engaging teaching methodologies. To address these learning barriers, innovative teaching strategies that leverage digital tools are essential. Studies suggest that when mathematics instruction incorporates real-life applications, multimedia content, and opportunities for self-paced learning, students are more likely to develop confidence and competence in the subject (Olufemi & Adebayo, 2022). Platforms like Khan Academy, which offer mastery-based learning and personalized feedback, can significantly improve students' academic performance and attitudes toward mathematics (Akinrinmade et al., 2021).

Concept and Nature of Khan Academy Learning Platform

Khan Academy is a globally recognized, non-profit educational platform that aims to provide free, world-class education to learners anywhere in the world. Founded by Salman Khan in 2008, the platform began as a series of online video tutorials created to support his cousin's math learning. What started as a personal tutoring effort quickly expanded into a full-scale educational initiative with millions of users worldwide (Oyeleke et al., 2022). Over time, Khan Academy evolved into a structured and comprehensive learning environment. With funding support from organizations such as Google and the Bill & Melinda Gates Foundation, the platform introduced advanced features, including adaptive learning technologies, mobile apps, and offline learning capabilities. By 2018, Khan Academy had reached over 18 million monthly active users, expanding its content across subjects like mathematics, science, computing, history, and economics. Despite this broad subject range, mathematics remains the platform's most widely accessed and impactful area (Banerjee et al., 2022). One of the core strengths of Khan Academy lies in its commitment to free, universally accessible education. All resources on the platform, including instructional videos, quizzes, and practice exercises are freely available to learners. This model is particularly beneficial for countries like Nigeria, where financial barriers often prevent students from accessing high-quality educational content. In this regard, Khan Academy contributes to educational equity by enabling self-paced, personalized learning regardless of socioeconomic background (Adeyemi et al., 2023).

The platform employs a mastery-based learning approach, which allows students to build competence in a topic before progressing. Unlike conventional education systems that move learners along a fixed timeline, Khan Academy ensures students thoroughly understand concepts through repeated practice and immediate feedback. This model is especially suited to mathematics, where foundational understanding is crucial to mastering more advanced topics (Li & Ma, 2021). Khan Academy's pedagogical design incorporates multimedia learning principles. Each lesson typically begins with a brief instructional video that visually explains a concept using diagrams, narration, and real-life examples. After the video, students engage in related practice exercises with hints and step-by-step solutions. This blend of visual instruction and interactive tasks helps reduce cognitive overload, making it easier for learners to retain complex mathematical ideas (Salami & Adeyemi, 2022). Moreover, Khan Academy features adaptive learning technology that customizes the learning experience based on student performance. The platform tracks user progress, identifies knowledge gaps, and recommends additional lessons. This functionality supports differentiated instruction, allowing both high-achieving and struggling students to engage with content that meets their individual needs (Olatunji et al., 2022). Teachers also benefit from this system, as it provides real-time analytics that highlight student performance trends, making it easier to offer targeted support. In addition to web access, Khan Academy offers mobile applications compatible with Android and iOS devices. The mobile app includes offline features that allow students to download lessons and exercises, an important advantage for users in areas with poor internet connectivity. In Nigeria, where many students rely on smartphones and where internet access is uneven, such features enhance the platform's usability and relevance (Afolayan & Balogun, 2021).

Another unique aspect of Khan Academy is its multilingual support. Although the platform is predominantly in English, many lessons have been translated into over 50 languages, making it accessible to non-English speakers. For countries like Nigeria, which is linguistically diverse, this feature paves the way for broader inclusivity. Efforts are ongoing to expand local language support, including Hausa, Igbo, and Yoruba, to better serve learners in remote regions. Beyond students, Khan Academy also offers resources for teachers and parents. Educators can create virtual classrooms, assign lessons, monitor progress, and provide timely feedback. Parents, on the other hand, can use the platform to guide and support their children's learning at home. This holistic model strengthens the learning ecosystem by actively involving all stakeholders (Bello & Yusuf, 2020).

Despite its numerous advantages, the effectiveness of Khan Academy in a developing country context hinges on infrastructure, digital literacy, and cultural alignment. Schools in under-resourced areas often lack internet access, functional ICT tools, or the training required to integrate Khan Academy into classroom instruction. Nonetheless, case studies from regions in India, South Africa, and Latin America indicate that when properly implemented, Khan Academy significantly improves student engagement, conceptual understanding, and academic performance in mathematics (Nguyen et al., 2020; Anderson & Walters, 2023). In Nigeria, the use of Khan Academy is growing steadily. It is increasingly used as a supplementary tool for mathematics instruction in schools and for national examination preparation. Studies show that Nigerian students who use the platform demonstrate improved confidence and problem-solving ability, particularly in mathematics (Eze & Oladipo, 2021). Some government and private education initiatives are already exploring how to integrate Khan Academy into public education through digital learning policies and school-based training programmes.

Methods

This study employed a quasi-experimental one-group pretest-posttest research design to evaluate the impact of the Khan Academy learning platform on the academic performance of junior secondary school students in mathematics. The research was conducted in two selected schools in Ilorin, Kwara State. One private and one public both serve as experimental groups where students received mathematics instruction supplemented by the Khan Academy platform. The participants were junior secondary school three (JSS3) students, aged 14 to 16 years, who actively engaged with Khan Academy's instructional videos, interactive exercises, and personalized learning tools to assess the platform's influence on their understanding and performance in mathematics. This design allowed for the measurement of student performance both before and after the intervention, providing insights into the effectiveness of technology-driven learning across different school settings within Kwara State.

The study utilized one primary research instrument which is the Mathematics Performance Test (MPT). The MPT consisted of 20 multiple-choice questions adapted from the Basic Education Certificate Examination (BECE), designed to assess students' performance after exposure to the Khan Academy intervention. A projector was also used to facilitate classroom access to Khan Academy resources, enhancing visual learning. The Khan Academy platform underwent validation to ensure its suitability for JSS3 students in Kwara State, involving content validity assessment against the mathematics curriculum and expert review of its instructional materials. A pilot test was conducted in a different school to gather feedback on the lessons' clarity and relevance. The MPT, being adapted from the BECE, was considered already validated, thus negating the need for a separate pilot study for this instrument.

Result

Table 1: Demography of Respondents

The sample consisted of 29 junior secondary school students distributed across two school types.

S/N	School Type	N	%
1	Private	09	31.0
2	Public	20	69.0
Total		29	

Private schools comprised most of the sample with 09 students (31.0%), while public schools contributed 20 students (69.0%).

Research Questions

Research Question One: What is the effect of Khan Academy Platform on the performances of junior secondary school students in Mathematics in private and public schools?

Table 2: Pre-Test and Post-Test Performances of Junior Secondary School Students taught Mathematics with Khan Academy Platform in Private schools

S/N		Pretest		Posttest		Mean Gain
		Mean	SD	Mean	SD	
1	29	52.4	18.88	72.07	13.40	19.93

Table 2 presents the pre-test and post-test performance results for 29 junior secondary school students from private schools who received mathematics instruction using the Khan Academy platform. The results demonstrate significant improvement in student performance, with mean scores increasing from 52.4 (*SD* = 18.88) at pre-test to 72.07 (*SD* = 13.40) on the post-test, yielding a mean gain of 19.93 points. This improvement represents a 38% increase in performance, moving students from the "Good" performance category to the "Excellent" category. Notably, the standard deviation decreased by 29% from pre-test to post-test, indicating that the intervention not only improved overall performance but also reduced achievement gaps among students.

Table 3: Pre-Test and Post-Test Performances of Junior Secondary School Students taught Mathematics with Khan Academy Platform in Public schools

S/N		Pretest		Posttest		Mean Gain
		Mean	SD	Mean	SD	
1	20	48.18	20.71	64.40	15.29	16.22

Based on Table 3, the implementation of Khan Academy platform for mathematics instruction among 20 junior secondary school students in public schools demonstrated substantial educational improvement and enhanced learning consistency. The students' mean performance increased significantly from 48.18 (SD = 20.71) in the pre-test to 64.40 (SD = 15.29) in the post-test, yielding a mean gain of 16.22 points, which represents approximately a 33.7% improvement in mathematical achievement. The concurrent reduction in standard deviation from 20.71 to 15.29 indicates that the Khan Academy platform not only facilitated overall academic improvement but also promoted more uniform learning outcomes across the student cohort, suggesting that the digital learning intervention effectively addressed individual learning differences and contributed to reduced performance variability while elevating the entire group's mathematical competency from below-average to above-average achievement levels.

Table 4: Pre-Test and Post-Test Performances of Junior Secondary School Students taught Mathematics with Khan Academy Platform in Private schools

S/N		Pretest		Posttest		Mean Gain
		Mean	SD	Mean	SD	
1	09	61.83	15.33	77.06	11.56	15.23

Based on the pre-test and post-test performance data, the implementation of Khan Academy platform for mathematics instruction among nine junior secondary school students in public schools demonstrated significant educational improvement and enhanced learning consistency. The students' mean performance increased substantially from 61.83 (SD = 15.33) in the pre-test to 77.06 (SD = 11.56) in the post-test, yielding a mean gain of 15.23 points, which represents approximately a 24.6% improvement in mathematical achievement. Notably, the reduction in standard deviation from 15.33 to 11.56 indicates that the Khan Academy platform not only facilitated overall academic improvement but also promoted more uniform learning outcomes across the student cohort, suggesting that the digital learning intervention effectively addressed individual learning differences and contributed to reduced performance variability while elevating the entire group's mathematical competency to higher achievement levels.

Discussion of Findings

The findings of this study provide valuable insights into the effectiveness of the Khan Academy platform as a digital learning intervention for mathematics instruction among junior secondary school students in Kwara State. The results demonstrate several key outcomes that warrant careful examination and interpretation within the broader context of educational technology integration in Nigerian secondary education. The study revealed moderate but meaningful academic improvements following the implementation of the Khan Academy platform (Smith & Johnson, 2022). Public school students demonstrated substantial learning gains, representing approximately one-third improvement from pre-test to post-test performance, with concurrent reduction in performance variability. This improvement pattern suggests that the platform's adaptive learning features, interactive content, and self-paced learning environment effectively addressed individual learning needs and contributed to enhanced mathematical competency (Chen et al., 2021). The magnitude of improvement aligns with previous research on digital learning platforms, which have consistently shown positive effects on student achievement when properly integrated into instructional practices (Williams & Brown, 2023). A particularly noteworthy finding was the reduction in standard deviation from pre-test to post-test across both school types, indicating that the Khan Academy platform not only improved overall performance but also promoted more consistent learning outcomes among students (Davis & Martinez, 2022). This reduction in variability suggests that the platform's personalized learning approach effectively addressed diverse learning needs and helped bridge achievement gaps within student cohorts (Thompson, 2021). The consistent performance improvement across different ability levels indicates the platform's potential for inclusive education and its capacity to support both struggling and advanced learners simultaneously (Anderson & Lee, 2023). The study revealed that private school students outperformed their public-school counterparts, with private school students achieving higher mean scores in both pre-test and post-test assessments (Wilson et al., 2022). However, the lack of statistical significance in this performance differential is particularly important, as it suggests that the Khan Academy platform's effectiveness transcends institutional boundaries and resource disparities (Roberts & Garcia, 2021). This finding challenges assumptions about the exclusive benefits of technology-enhanced learning in well-resourced private institutions and demonstrates the platform's potential for democratizing quality mathematics education across diverse educational contexts (Kumar & Patel, 2023).

The moderate academic improvements observed in this study align with the growing body of evidence supporting technology-enhanced learning environments (Miller & Clark, 2022). The Khan Academy platform's effectiveness appears to stem from its combination of visual representations, immediate feedback mechanisms, and adaptive sequencing of learning content (Taylor & White, 2021). These features address key challenges in traditional mathematics instruction, including limited individualization, insufficient practice opportunities, and inadequate immediate feedback (Johnson & Adams, 2023). The platform's ability to provide personalized learning pathways while maintaining curriculum alignment represents a significant advancement in addressing diverse learning needs within classroom settings (Brown & Wilson, 2022).

While the findings are encouraging, several contextual factors must be considered when interpreting these results (Lewis & Turner, 2021). The study's focus on Kwara State provides insights specific to this educational context, but generalizability to other Nigerian states or international contexts may be limited by variations in infrastructure, teacher training, and educational policies (Okonkwo & Adebayo, 2022). Additionally, the moderate nature of the improvements suggests that while the Khan Academy platform is beneficial, it should be viewed as a complementary tool rather than a replacement for effective traditional instruction (Green & Harris, 2023). The integration of digital platforms requires careful consideration of local educational priorities, resource availability, and pedagogical approaches to maximize effectiveness (Sharma & Reddy, 2021).

Conclusion

The study demonstrated that implementation of the Khan Academy Learning Platform resulted in moderate academic improvement among junior secondary school students in Kwara State. While students in private schools exhibited superior performance compared to their public school counterparts, the observed variation in achievement based on school type did not reach statistical significance. These findings suggest that the Khan Academy platform demonstrates considerable potential as an effective digital tool for enhancing mathematics learning outcomes across different educational contexts within the region, indicating its utility for improving mathematical competency regardless of institutional type.

Recommendations

Based on the study findings, the following recommendations were made

1. Educational authorities in should develop comprehensive teacher training programs focused on effective integration of the Khan Academy platform into existing mathematics curricula, emphasizing pedagogical strategies for blended learning approaches and technical proficiency to maximize observed learning gains across both public and private school settings.

2. Policymakers should prioritize investment in digital infrastructure, particularly in public schools, to ensure equitable access to reliable internet connectivity and adequate technological resources that would support broader Khan Academy platform implementation and help bridge performance gaps between school types.

3. Education stakeholders should establish ongoing evaluation mechanisms to assess long-term impact of Khan Academy platform usage while implementing systematic curriculum alignment processes to ensure platform content corresponds with local mathematics standards and optimize academic effects for potential scaling across additional schools in the region.

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PERSONALISED LEARNING IN ENHANCING THE TEACHING OF PHYSICS EDUCATION USING ARTIFICIAL INTELLIGENCE TOOLS

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Abstract

Artificial Intelligence (AI) is rapidly reshaping education by enabling personalised learning that adapts to individual student needs, pacing, and proficiency levels. In the context of Physics education—where abstract and mathematically intensive topics such as motion, energy, and electromagnetism often challenge learners—AI offers innovative solutions that transform both teaching and learning experiences. This paper explores the impact of AI-driven personalised learning tools in enhancing the comprehension and engagement of students studying Physics. Using a mixed-methods approach, the study evaluates the integration of adaptive platforms such as PhET Interactive Simulations, ChatGPT, and Newton AI in teaching secondary and tertiary Physics students. These tools offer real-time feedback, dynamic simulations, and customised content delivery based on learner responses. Data from pilot sessions and classroom interventions suggest significant improvement in students' conceptual understanding, increased time-on-task, and better performance in formative assessments compared to traditional lecture methods. The paper further highlights how AI enables struggling learners to receive scaffolded instruction, while also challenging advanced students through accelerated modules. The findings advocate for the inclusion of AI-powered personalised learning environments in STEM pedagogy, with a particular emphasis on Physics due to its abstract and often inaccessible nature. The study concludes with practical recommendations for educators, curriculum designers, and policy makers on mainstreaming AI in Physics instruction to foster academic excellence.

Keywords: Artificial Intelligence, Personalised Learning, Physics Education, STEM Pedagogy, Adaptive Learning Technologies

Introduction

Physics, as a foundational pillar of science, plays a critical role in shaping students' understanding of the natural world. However, it remains one of the most challenging subjects for learners across secondary and tertiary education levels. The abstract nature of key Physics concepts—such as force, electromagnetism, thermodynamics, and quantum theory—often leads to confusion, disengagement, and poor academic performance. Traditional classroom methods, typically dominated by lectures and textbook-based instruction, fail to address diverse learning styles, leading to low retention and reduced interest in STEM pathways (Fu et al., 2021). In response to these pedagogical challenges, Artificial Intelligence (AI) has emerged as a transformative force in education. AI-powered systems can deliver personalised learning experiences by adapting content, pace, and feedback to individual learner profiles. From intelligent tutoring systems to virtual labs and adaptive assessment tools, AI is reshaping the delivery of scientific education, making abstract concepts more tangible, interactive, and student-centred (Veksler et al., 2020).

This paper investigates the potential of AI-enabled personalised learning to enhance the teaching and learning of Physics. It focuses on how AI technologies can improve students' conceptual understanding, problem-solving skills, and engagement.

The study is guided by two central research questions:

1. *How can AI adapt teaching to students' learning styles in Physics?*
2. *What AI tools are best suited for teaching abstract Physics concepts such as motion, energy, and electromagnetism?*

Literature Review

AI is redefining the landscape of education through personalised, data-driven learning experiences. Adaptive learning systems use real-time analytics to modify content delivery based on students' performance, while intelligent tutoring systems offer tailored guidance and remedial support. Tools like Squirrel AI, Carnegie Learning, and Khan Academy exemplify how AI tracks learner patterns, adjusts difficulty levels, and provides instant feedback. Feedback engines evaluate student responses, flag errors, and offer explanatory suggestions (Malche et al., 2022). These systems foster learner autonomy and allow instructors to focus on conceptual facilitation rather than rote delivery. In STEM subjects, AI aids in breaking down complex ideas into manageable learning units. Its growing adoption has led to increased engagement, improved performance metrics, and broader access to quality instruction. As such, AI is no longer supplementary—it is becoming central to 21st-century teaching and learning, especially in technical fields such as Physics, where adaptability and clarity are crucial (Shamout et al., 2022).

Physics instruction often relies heavily on textbook-based content, static illustrations, and formulaic problem-solving, which fail to address students' varying learning needs. Traditional methods emphasise memorisation over inquiry, offering limited opportunities for students to visualise or simulate real-world phenomena. Many Physics concepts—such as electromagnetism, wave behavior, or relativity—are abstract and non-intuitive, making it difficult for learners to relate them to daily experiences. In overcrowded classrooms, teachers may lack the time and resources to provide differentiated instruction or hands-on experiments. Assessments are often summative, offering little timely feedback for course correction. This rigid model contributes to learner disengagement, low retention, and poor conceptual understanding. As a result, many students perceive Physics as overly theoretical and inaccessible. Addressing these challenges requires a shift toward more personalised, interactive, and visually rich teaching approaches—an area where Artificial Intelligence holds strong potential (de-Lima-Santos et al., 2022; Shamout et al., 2022).

One of AI's most impactful applications in Physics education is its ability to support visual and interactive learning. AI-powered platforms integrate simulations, augmented reality (AR), and virtual labs that make abstract concepts more concrete. For example, PhET Interactive Simulations allow students to manipulate variables in real time, observing the effects of changes in motion, force, or electric fields. AI also powers platforms like Labster, which offers virtual science experiments that replicate real lab environments. These tools help bridge the gap between theory and application, particularly in under-resourced schools with limited laboratory access (Kognisi et al., 2021). Moreover, AI-generated visualisations can be personalised based on a learner's progress and misconceptions. This dynamic, engaging approach transforms the way students interact with Physics content, turning passive observation into active exploration. By enabling learners to experiment, visualise, and receive immediate feedback, AI fosters deeper conceptual understanding and supports multiple learning styles simultaneously (Ramatov, 2020).

Several case studies across the globe demonstrate how AI enhances STEM education, particularly in improving conceptual grasp. At Stanford University, an AI-enhanced tutoring system helped engineering students master thermodynamics by adapting lesson plans based on their pace and quiz scores. In China, Squirrel AI significantly boosted mathematics and science scores by tailoring instruction to individual weaknesses. Closer to subject relevance, the use of IBM Watson in high school Physics classes enabled students to access real-time answers to Physics queries, while guiding them through logic-based problem solving. In Nigeria, pilot programs using platforms like uLesson and virtual simulators showed measurable gains in understanding concepts like projectile motion and energy conservation. These studies consistently report higher engagement, improved critical thinking, and better retention among learners exposed to AI-enhanced content. While varied in context, they all affirm AI's ability to personalise instruction and simplify complexity, particularly in traditionally difficult STEM fields like Physics (Tjebane et al., 2022).

Despite AI's growing role in education, several gaps hinder its widespread impact in Physics classrooms. First, infrastructure limitations—such as internet access, power supply, and digital devices—restrict AI deployment in under-resourced regions. Secondly, many educators lack adequate training to integrate AI tools effectively, resulting in low adoption or superficial use. Third, while there are numerous AI platforms, few are tailored specifically to Physics pedagogy or aligned with national curricula (Zaccheaus, 2019). Research is also lacking on the long-term effects of AI use on conceptual mastery and learner independence in Physics. Additionally, ethical concerns around data privacy, over-reliance on automated systems, and algorithmic bias remain under-explored. Finally, there is insufficient documentation on how AI tools perform across different learner demographics, such as gender, language background, and learning disabilities. These gaps highlight the need for context-sensitive, curriculum-aligned, and ethically grounded AI integration strategies, especially in developing countries and complex subjects like Physics (Sadiq et al., 2018).

Methodology

The study used a mixed-methods approach to evaluate the impact of AI-enabled personalised learning on Physics education. It involved 90 secondary and early tertiary-level learners from three Nigerian schools, who were introduced to AI-powered instructional tools over a six-week intervention period. The tools used included PhET Simulations for real-time experiments, ChatGPT for conceptual explanations, uLesson AI Module & Newton AI for adaptive video lessons, and Google Classroom/Forms for data collection and digital testing. Students were grouped into a control group, which used traditional methods, and an experimental group, which used AI-supported learning pathways with visual simulations and feedback loops. Data collection methods included pre/post-test scores, student focus group feedback, teacher observation logs, and AI tool usage analytics. The study provides a holistic view of how AI impacts academic performance and learner experience in Physics education.

Application of AI for Personalised Physics Learning

AI enables tailored instruction that aligns with each learner's pace, proficiency, and preferred learning style. In Physics—where conceptual clarity and mathematical accuracy are critical—AI tools provide dynamic, engaging, and adaptive environments that strengthen both foundational understanding and advanced problem-solving skills.

1. Adaptive Learning Platforms: AI-powered adaptive learning platforms dynamically adjust the difficulty and sequencing of content based on a student's performance. These systems analyse responses in real time, identifying learning gaps and immediately adapting

subsequent problems or explanations. In Physics education, such platforms present varying levels of questions on motion, energy, or electromagnetism, ensuring students remain challenged but not overwhelmed. For instance, tools like Newton AI or uLesson's adaptive video modules modify problem sets based on learner accuracy and response time. A student struggling with Newton's Laws might receive additional visual examples and simplified questions before progressing. These platforms also provide real-time feedback during quizzes or interactive activities, guiding students to correct errors and reinforcing learning through repetition and scaffolding (Shrivastava & Johari, 2022).

2. Intelligent Tutoring Systems (ITS): AI-based Intelligent Tutoring Systems simulate 1-on-1 teaching by offering personalised guidance, question-answering, and step-by-step solutions. Tools like ChatGPT and Socratic by Google act as virtual tutors that support conceptual exploration and targeted remediation. For example, when a learner enters a question about thermodynamic laws or equations of motion, ChatGPT can provide both an intuitive explanation and a worked-out solution, tailored to the learner's current level of understanding. ITS can also respond to follow-up questions, recognise misconceptions, and adjust explanations in real-time. This form of learning is especially valuable for students needing individual attention or those learning outside the classroom environment (Wong et al., 2022).
3. Concept Visualisation and Virtual Labs: Physics relies heavily on abstract, often invisible phenomena—such as force fields, wave energy, and electric currents. AI-integrated visualisation tools and virtual labs make these concepts tangible. Platforms like PhET Interactive Simulations allow students to manipulate variables in real-time, visualising relationships between force, mass, and acceleration or exploring electric circuits and magnetic fields. Further, immersive AR/VR-based labs (e.g., Labster, Merge EDU) simulate laboratory environments where students can explore Physics experiments without the limitations of physical labs. These experiences are tailored to student pace and learning style, allowing learners to revisit simulations as needed. By offering experiential, self-directed learning, these tools reduce abstraction, improve retention, and foster deeper conceptual understanding, especially for kinaesthetic and visual learners (Berahas et al., 2023).

Educational Impact

1. Improved Understanding of Core Physics Concepts

One of the most significant impacts of AI in Physics education is the deepened understanding of core concepts such as motion, energy conservation, electromagnetism, and thermodynamics. AI-powered simulations allow learners to visualize forces and interactions that are otherwise abstract or invisible. For example, using PhET simulations, students can see how changing mass or velocity affects kinetic energy in real time. Such dynamic, visual demonstrations reinforce learning better than textbook descriptions. Additionally, AI tools like ChatGPT or Newton AI can break down complex equations into manageable, step-by-step explanations, tailored to individual understanding levels. Students struggling with concepts like Newton's Third Law can receive multiple simplified explanations, analogies, or examples until comprehension is achieved. When paired with virtual experiments, learners can test these principles independently, boosting both conceptual clarity and critical thinking (Berahas et al., 2023). Case feedback from three secondary schools using AI tools in Nigeria showed a 30–40% improvement in students' ability to explain force and energy interactions post-intervention. Students previously unable to solve force diagrams were now confident in analyzing vector directions and magnitudes, indicating that AI tools play a crucial role in turning difficult theory into digestible and retainable knowledge (Zhang & Zhang, 2020).

2. Enhanced Student Engagement and Autonomy

Traditional Physics classrooms often rely on lecture-based instruction, which may lead to student disengagement, especially when the content feels irrelevant or difficult to grasp. AI tools address this by making learning interactive, responsive, and student-centered. With adaptive platforms, students control their pace and explore topics in a non-linear fashion. This fosters ownership of learning, which is essential for long-term academic growth. Platforms like uLesson's AI-integrated lessons and Socratic by Google keep students engaged through gamified quizzes, instant feedback, and visual challenges. A student struggling with Ohm's Law can receive a visual breakdown of circuits and voltage, retry tasks, and move on only when ready. Similarly, gifted learners can bypass repetitive topics and dive into more advanced simulations or problems. In our pilot study, students reported higher motivation and focus when using AI-based learning platforms compared to textbooks or lectures. Time-on-task improved by 35%, and off-task behavior dropped significantly. Students especially appreciated being able to "ask" AI tools for clarification without fear of judgment, enhancing their confidence and independence. This shift from passive reception to active exploration transforms Physics from an intimidating subject to an accessible and exciting journey (Ali et al., 2019).

3. Better Performance in Assessments

AI-driven personalized learning models enhance not only understanding but also student performance in both formative and summative assessments. By providing immediate feedback and adaptive practice, these systems help students identify their weaknesses early and correct them before final evaluations. In Physics, where minor errors in calculation or concept application can drastically affect grades, this is particularly beneficial. Students who used AI tools such as ChatGPT for concept clarification and PhET for simulation-based learning showed noticeable improvement in test scores. In a controlled study involving 90 students, the experimental group using AI tools outperformed the traditional group by an average of 22% in post-intervention Physics assessments. The most significant gains were observed in problem-solving sections related to projectile motion, circuit analysis, and energy transformations. Moreover, AI systems allow for continuous low-stakes testing, which reduces exam anxiety and builds mastery over time. Students become accustomed to evaluating their progress, leading to better metacognitive skills. These tools also help teachers identify struggling learners early through usage analytics, allowing for timely intervention. The result is not just better grades, but more confident, competent Physics students with a stronger foundation for advanced study (Pezeshki et al., 2019).

4. Support for Struggling Learners and Gifted Students Alike

AI enables differentiated instruction, a practice essential for accommodating the wide range of abilities within a single classroom. In traditional Physics classes, struggling students often fall behind, while high achievers may feel held back. AI platforms solve this by adapting content delivery in real time, ensuring every learner receives instruction at the appropriate level of challenge. For instance, struggling students benefit from scaffolded explanations, multiple-choice diagnostics, and remedial problem sets. A student weak in kinematics can work through step-by-step tutorials with visual aids, reinforcing concepts through repetition and interactivity. On the other hand, gifted students can skip review content and engage with enrichment materials, like advanced simulations, real-world physics problems, or even introductory coding exercises in physics modelling. Feedback from Physics teachers at Padle Healthcare Limited’s outreach partner schools reported that AI tools allowed better classroom management, as students were occupied with personalized content. One teacher noted a 50% drop in repeated clarifications for basic concepts, while another observed that high performers completed the syllabus early and began independent projects. AI thus fosters inclusive excellence, where all students are supported and challenged at their level (Wawire et al., 2023).

5. Case Evidence and Preliminary Data Analysis

A field trial was conducted across three Nigerian secondary schools with a combined sample of 90 students (divided evenly between a control and experimental group). The experimental group used AI tools such as PhET simulations, ChatGPT, and Newton AI alongside teacher instruction, while the control group followed conventional teaching methods. Pre-tests and post-tests were administered to both groups, along with weekly feedback sessions and usage monitoring. Initial data analysis showed that the experimental group experienced significant academic gains, with mean post-test scores increasing from 42% to 74%, compared to the control group’s rise from 44% to 59%. Improvements were most prominent in conceptual topics like energy conservation and circular motion, which were reinforced through AI simulations and adaptive practice. Qualitative feedback highlighted that students enjoyed the AI interfaces, appreciated learning at their own pace, and felt more confident asking AI systems questions they were hesitant to ask teachers. Teachers observed increased participation, reduced absenteeism, and a stronger culture of self-directed learning. These findings support the claim that AI not only improves academic performance but also transforms the learning experience, making Physics more accessible, engaging, and student-centered.

Challenges and Ethical Concerns

1. Equity in Access to AI Tools: One of the foremost challenges in implementing AI in Physics education is unequal access to technology. In many regions—particularly rural and underserved communities—students lack reliable internet, smart devices, or even electricity. These infrastructure gaps create a digital divide that prevents equitable participation in AI-enhanced learning. For instance, while urban schools may adopt virtual labs and adaptive platforms, rural schools may still rely solely on chalkboards and printed notes. This disparity risks widening the achievement gap between students who have access to AI and those who don’t. At Padle Healthcare Limited’s outreach schools, some learners had to share mobile devices or study offline due to connectivity issues, limiting the impact of AI-based programs. To ensure inclusive innovation, educational stakeholders must invest in low-bandwidth, offline-compatible AI tools and infrastructure development. Without proactive equity planning, AI risks reinforcing existing educational inequalities rather than resolving them (Mudzielwana, 2014).

2. Data Privacy and Tracking Concerns: AI platforms rely heavily on collecting user data—such as performance scores, behavior patterns, and response times—to personalize instruction. While this enhances learning precision, it also raises significant data privacy and ethical concerns, especially when involving minors. Improper storage, third-party data sharing, or security breaches could expose sensitive student information. Most free or commercial AI tools are governed by private companies, and users (especially in public schools) may lack transparency about how their data is collected, stored, or used. At Padle Healthcare Limited's trial sites, parents expressed concern over student data being uploaded to cloud platforms without clear policies in place. To mitigate risks, institutions must adopt clear consent protocols, use tools compliant with data protection regulations (like GDPR or NDPR), and train staff on responsible data practices. AI integration in education must be accompanied by strong data ethics frameworks to ensure that personalization does not come at the cost of student privacy or security (Khalid Khan et al., 2023).

3. Need for Teacher Re-Training to Integrate AI: Despite the growing availability of AI tools, their effective classroom use depends on teacher competence and confidence. Many Physics educators lack the technical background or digital literacy required to integrate AI platforms into their instruction meaningfully. This results in underutilization of available tools or reliance on outdated teaching methods. For instance, some teachers in the pilot project hesitated to use simulation software due to unfamiliarity with its interface. Others struggled to interpret AI-generated analytics, which are vital for adjusting instruction. This training gap limits the full potential of AI in fostering personalized learning. To overcome this, education systems must invest in ongoing professional development, focusing not just on tool operation but on pedagogical strategies for integrating AI into lesson planning, assessment, and classroom management. Teachers must evolve from being content deliverers to facilitators of AI-supported inquiry, and they cannot do this without structured support, mentorship, and accessible training resources (Gao et al., 2021).

4. Risk of Over-Reliance on AI at the Expense of Scientific Thinking: While AI enhances personalization and engagement, over-reliance on it can undermine core scientific competencies. Students may become too dependent on AI-generated solutions or simulations, reducing their ability to perform manual calculations, design experiments, or critically assess outcomes. This could lead to surface-level understanding without the deep cognitive engagement necessary for Physics mastery. For example, a student relying solely on AI to solve equations may struggle to understand the underlying principles of kinematics or thermodynamics. Similarly, students may accept AI explanations without questioning or verifying them—a habit contrary to the scientific method. At Padle Healthcare Limited's trials, teachers noted that some students began to skip practice problems, assuming AI feedback alone was sufficient. To prevent this, educators must balance AI use with inquiry-based tasks, lab experiments, and peer discussion. AI should complement, not replace, scientific reasoning. Learners must be taught to interrogate AI outputs, cross-check predictions, and reflect critically, developing habits essential for future scientists and researchers (Duymaz & Tekin, 2023).

Recommendations

1. Integrate AI Tools into National Physics Curriculum: To fully leverage AI's potential, education ministries and curriculum bodies must move beyond pilot projects and embed AI tools into the formal Physics curriculum. This integration should not treat AI as an add-on but as a core instructional medium, especially for complex topics like electromagnetism, thermodynamics, and quantum mechanics. Curriculum frameworks should provide guidelines on the use of adaptive platforms, simulations, and AI-generated feedback tools, including when and how they should be applied during instruction and assessment. For example, topics such as Newton's Laws or projectile motion can explicitly include AI-based simulations like PhET or Labster as part of the teaching resource pack. Aligning national assessments with AI-supported instruction ensures consistency, credibility, and scalability. Without such structural alignment, AI-enhanced learning risks remaining fragmented and dependent on individual teacher initiative. National policy adoption can also drive public-private partnerships that fund and monitor the ethical, pedagogical, and technological dimensions of AI deployment.

2. Provide Continuous Training for Physics Educators on Using AI: Teachers are the linchpin in any educational reform. To ensure effective and ethical use of AI in Physics education, institutions must invest in ongoing, hands-on training for educators. Training should go beyond basic tool use—it must focus on integrating AI into lesson planning, formative assessment, and differentiated instruction. Educators need to understand how to interpret AI-generated learning analytics, how to scaffold students' interactions with virtual labs, and how to balance AI with inquiry-based teaching. For example, a Physics teacher learning how to use Newton AI should also learn how to translate AI output into actionable feedback for students. These training programs should be embedded within national teacher development frameworks and offered via workshops, online courses, and peer mentoring. Without such support, even the best AI tools may be misused or underused, leading to inconsistent learner outcomes. Teacher empowerment is essential for building trust in AI and maximizing its pedagogical value.

3. Encourage Research-Practice Collaboration for Tool Improvement: To keep AI tools responsive and relevant, there must be a strong feedback loop between developers and educators. Universities, EdTech startup, and schools should form interdisciplinary partnerships that allow teachers to test new AI features in real classrooms and share practical insights with developers. For instance, Physics teachers could report on how students interact with AI simulations of wave interference or circuits, informing tool refinement. These collaborations ensure that AI platforms evolve based on pedagogical needs, not just technical possibilities. Government agencies and education research institutes should fund joint studies that explore AI's long-term impact on learning outcomes, student attitudes, and equity. Such partnerships can also lead to the creation of localized AI models that reflect national curricula and student contexts. When researchers and practitioners co-design tools, the result is more effective, inclusive, and adaptable AI solutions for Physics education.

4. Invest in Open-Source AI Learning Platforms for Equitable Access: To bridge the digital divide, stakeholders must prioritize the development and dissemination of open-source AI platforms that are free, customizable, and accessible offline or on low-bandwidth networks. Proprietary AI tools often require costly subscriptions, licenses, or internet connectivity, excluding many learners in low-income or rural communities. By contrast, open-source platforms like DeepChem, OpenAI APIs, and Google Colab-based simulations can be adapted for educational use at scale. Government and donor agencies should fund local versions of these tools that align with national Physics syllabi and languages. Teacher training colleges should also include open-source toolkits in their curriculum to ensure graduates are AI-literate from the start. Investing in equitable AI infrastructure ensures that all students—regardless of geography or socioeconomic status—benefit from personalized learning. Equity in access is not just a moral imperative; it is essential for national competitiveness in a technology-driven world.

Conclusion

AI presents a scalable and transformative solution to many of the long-standing challenges in Physics education. By offering adaptive content delivery, real-time feedback, and visual simulations, AI tools bridge the gap between abstract theory and student understanding, making Physics more accessible, engaging, and relevant. These technologies empower both teachers and learners by creating flexible environments where progress is individualized and mastery is supported, regardless of prior ability or background. Personalized learning—driven by AI—has demonstrated clear gains in student comprehension, retention, and performance, particularly when dealing with complex topics like motion, energy, and electromagnetism. Students benefit from tailored pacing, differentiated problem sets, and interactive experimentation, while educators gain insight into student needs through usage data and predictive analytics. However, to fully realize this potential, systemic change is essential. Educational institutions, curriculum designers, and policymakers must take deliberate steps to integrate AI tools into mainstream STEM instruction. This includes updating national curricula, training educators, and investing in equitable AI infrastructure. Without such coordinated action, AI risks becoming a tool for the few rather than a standard for the many.

In conclusion, integrating AI into Physics education is not just a technological upgrade—it is a pedagogical imperative that can drive academic excellence and prepare learners for the demands of a data-driven future.

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TEACHING APPROACHES IN LAGOS STATE PRIMARY SCHOOLS: COMPARING TRADITIONAL LESSONS, EKO EXCEL, AND THE UNIFIED LESSON PLAN

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Abstract

This study investigates teachers' perceptions and experiences regarding the implementation of three distinct teaching methodologies in Lagos State primary schools: Traditional Lessons, Eko Excel, and the Unified Lesson Plan. Educational reform in developing nations represents a complex undertaking, particularly when multiple approaches coexist within a single system. Using a mixed-methods research design, the study collected data from 566 teachers through questionnaires and conducted focus group discussions with 15 educators in Badagry Local Government Education Authority. Findings reveal a clear hierarchical preference among teachers, with 62.5% favoring the Unified Lesson Plan due to its structured yet flexible framework that preserves teacher autonomy. Eko Excel (27.6%) and Traditional Methods (9.9%) received significantly lower preference ratings. Quantitative and qualitative analyses demonstrate that both Traditional Methods and Eko Excel present substantial challenges in time management and resource utilization, with 76.3% and 68.2% of teachers reporting time consumption challenges respectively. Technological reliability emerged as a critical differentiator, with 76.4% of teachers reporting system breakdowns with Eko Excel implementation. The research provides empirical support for Rogers' Diffusion of Innovation Theory and Bandura's Self-Efficacy Theory, highlighting how technological adoption and teacher beliefs influence implementation success. The findings emphasize that successful educational transformation extends beyond technological implementation, requiring comprehensive approaches that consider teacher experiences, professional development, and contextual adaptability. Recommendations include targeted technological integration training and continuous refinement of the Unified Lesson Plan based on teacher feedback.

Keywords: Eko Excel, Traditional Lessons, Unified Lesson plan

Introduction

Education has been widely recognized as a fundamental driver of societal development and economic growth, particularly in developing nations striving to build competitive knowledge economies. The evolution of educational systems worldwide reflects an ongoing journey to discover and implement the most effective teaching and learning methodologies that can prepare students for the challenges of an increasingly complex world (Darling-Hammond et al., 2020). In Nigeria, particularly Lagos State, this evolution has taken on unique characteristics shaped by local contexts, cultural considerations, and technological advancement. The historical context of education in Lagos State provides essential insights into the current landscape. Since Nigeria's independence in 1960, Lagos State has emerged as a pioneer in educational innovation within the country. The state's position as Nigeria's economic hub has created both opportunities and challenges in its educational sector, leading to various reforms aimed at improving teaching quality and student outcomes (Oyewole & Adebayo, 2023). These reforms have been particularly crucial given Lagos State's rapid population growth and urbanization, which have placed increasing demands on its educational infrastructure.

Traditional teaching methods, which have been the backbone of education in Lagos State for many decades, evolved from a combination of colonial educational heritage and indigenous teaching practices. These methods typically involve teacher-centered instruction, with emphasis on lecture-style delivery, rote learning, and standardized assessments. While this approach has produced generations of educated Nigerians, research by Johnson and Smith (2022) indicates significant limitations in meeting contemporary educational needs, particularly in developing critical thinking skills and promoting student engagement. The traditional lesson approach, while familiar and deeply ingrained in the educational culture, has faced mounting criticism for several reasons. First, it often fails to accommodate different learning styles and abilities within the classroom. Second, it may not adequately prepare students for the technological demands of the modern workplace. Third, it can limit opportunities for meaningful student participation and collaborative learning experiences (Thompson et al., 2023). These limitations became particularly evident as global educational discourse shifted towards more student-centered, technology-enhanced learning approaches.

Recognizing these challenges, the Lagos State Government initiated a series of educational reforms aimed at transforming teaching and learning practices. One of the most significant initiatives was the introduction of the Eko Excel (Excellence in Child Education and Learning) program in 2019. Eko Excel is a multifaceted program that includes several tactics and interventions to empower teachers, create a positive learning atmosphere and give pupils the tools they need to succeed in school (Malik, Alordiah, & Moemeke, 2024). The Eko Excel initiative was designed not merely as a technological upgrade but as a comprehensive transformation of the teaching and learning experience. The Eko Excel program introduces several innovative features that distinguish it from traditional teaching methods. Teachers are equipped with tablets containing pre-loaded content, lesson plans, and assessment tools. This digital approach enables real-time tracking of lesson delivery and student progress, providing valuable data for educational planning and intervention. The program also includes professional development components, ensuring that teachers receive ongoing support in implementing new teaching methodologies (Anderson & Williams, 2023).

Furthermore, the program emphasizes the importance of structured pedagogy, which includes carefully designed lesson plans that integrate active learning strategies, formative assessment techniques, and opportunities for student interaction. This structured approach aims to ensure consistency in educational delivery while maintaining high standards across different schools and communities within Lagos State. Building on these reforms, the Lagos State Government recently introduced the Unified Lesson Plan initiative. This standardized approach to lesson planning and delivery represents an attempt to bridge the gap between traditional methods and modern pedagogical practices while ensuring consistency across the state's educational system. The Unified Lesson Plan framework provides teachers with structured guidelines while allowing for creativity and adaptation to local contexts.

Research by Roberts and Chen (2023) suggests that successful educational reform requires careful consideration of local contexts, teacher capacity, and available resources. The coexistence of different teaching approaches in Lagos State raises important questions about their compatibility, effectiveness, and impact on teacher performance and student learning outcomes. Understanding how teachers perceive and experience these different approaches becomes crucial for ensuring their successful implementation and achieving desired educational outcomes.The global context of educational reform also influences Lagos State's initiatives. International studies have shown that successful educational transformation requires a balanced approach that considers both pedagogical innovation and practical implementation challenges (Wilson & Kumar, 2023). The experiences of other countries in implementing similar reforms provide valuable insights for understanding the potential challenges and opportunities in Lagos State's context.

Additionally, the COVID-19 pandemic has accelerated the need for technological integration in education and highlighted the importance of flexible teaching approaches. The pandemic-induced shift to remote learning demonstrated both the potential and limitations of different teaching methodologies, making it even more crucial to understand how teachers adapt to and implement various approaches (Thompson & Garcia, 2024). The role of teacher professional development has emerged as a critical factor in the successful implementation of these various teaching approaches. Research indicates that teachers require ongoing support, training, and resources to effectively integrate new methodologies into their practice (Anderson & Williams, 2023). Understanding teachers' perceptions and experiences becomes essential for designing appropriate professional development programs and support systems.

Moreover, the sociocultural context of Lagos State adds another layer of complexity to the implementation of different teaching approaches. Teachers must navigate cultural expectations, community perspectives, and local educational traditions while implementing new methodologies. This cultural dimension influences how teachers perceive and adapt different teaching approaches to meet their students' needs (Oyewole & Adebayo, 2023). The economic implications of implementing multiple teaching approaches also warrant consideration. While initiatives like Eko Excel represent significant investments in educational technology and teacher training, traditional methods continue to play a vital role, particularly in resource-constrained settings. Understanding how teachers experience and adapt these approaches in different economic contexts becomes crucial for ensuring equitable educational delivery across Lagos State.

Statement of the Problem

The implementation of multiple teaching approaches in Lagos State's educational system presents a complex challenge that requires careful examination. Despite significant investments in educational reforms and the introduction of innovative teaching methodologies, there remains a critical gap in understanding how teachers perceive and experience these different approaches in their daily practice. This gap poses several interconnected problems that merit systematic investigation.

The first fundamental problem lies in the limited empirical evidence regarding the effectiveness of these teaching approaches from the teachers' perspective. While previous studies have extensively documented student outcomes and administrative metrics, they have largely overlooked the crucial role of teacher experiences and perceptions in successful implementation (Thompson et al., 2023). This oversight is particularly problematic because teachers serve as the primary agents of educational change, and their understanding, acceptance, and effective implementation of these approaches directly influence student learning outcomes.

Research by Avidov-Ungar et al. (2023) indicates that educational reforms often fail not due to inherent flaws in the initiatives themselves, but rather due to insufficient attention to teacher perspectives and implementation challenges. In the context of Lagos State, where Traditional Lessons and Eko Excel has been tried, understanding the perception of teachers about these different approaches becomes crucial for sustainable educational improvement.

Another significant aspect of the problem lies in the potential disconnect between policy intentions and classroom realities. The simultaneous implementation of multiple teaching approaches has created a complex teaching environment that may lead to confusion, inconsistency, or even resistance among teachers. Without a clear understanding of how teachers perceive and experience these approaches, it becomes challenging to identify and address implementation barriers effectively (Roberts & Chen, 2023).

Furthermore, the problem extends to the practical challenges of resource allocation and professional development. Teachers in Lagos State must adapt to new technological tools embedded in the Eko Excel programme while maintaining proficiency in traditional teaching methods. This multi-faceted requirement places significant demands on teachers' time, skills, and resources. Understanding these demands from the teachers' perspective is essential for developing appropriate support systems and professional development programmes (Al-Mughairi & Bhaskar, 2024).

The socioeconomic disparities within Lagos State add another layer of complexity to the problem. Schools in different areas face varying levels of resource availability, technological infrastructure, and community support. These disparities may influence how teachers perceive and implement different teaching approaches, potentially leading to inequitable educational experiences across the state. Without a comprehensive understanding of these variations, it becomes difficult to ensure consistent and effective implementation of educational reforms (Wilson & Kumar, 2023).

Additionally, there is a concerning lack of documentation regarding the challenges and opportunities teachers encounter when implementing these different approaches. While anecdotal evidence suggests various implementation difficulties, systematic research is needed to identify specific barriers and enablers of successful implementation. This knowledge gap hampers efforts to optimize these teaching approaches and provide targeted support to teachers (Anderson & Williams, 2023).

The problem also encompasses the potential impact of cultural and contextual factors on teaching approach implementation. Lagos State's diverse cultural landscape means that teachers must navigate various cultural expectations and community perspectives while implementing new teaching methodologies. Understanding how these cultural factors influence teacher perceptions and experiences is crucial for developing culturally responsive implementation strategies (Oyewole & Adebayo, 2023).

Moreover, the rapid pace of technological change and educational innovation creates an ongoing challenge for teachers trying to maintain effectiveness across different teaching approaches. The COVID-19 pandemic has accelerated the need for technological integration in education, adding urgency to understanding how teachers adapt to and implement various teaching methodologies in both traditional and technology-enhanced contexts (Thompson & Garcia, 2024).

The problem also extends to the assessment and evaluation of these teaching approaches. Without a clear understanding of teacher perspectives and experiences, it becomes difficult to develop appropriate metrics for measuring the effectiveness of different approaches and identifying areas for improvement. This challenge is particularly significant given the need to ensure that educational reforms lead to meaningful improvements in teaching quality and student learning outcomes (Johnson & Smith, 2022).

The lack of comparative analysis between different teaching approaches from the teacher's perspective also poses a significant problem. While each approach has been studied individually to some extent, there is limited research comparing how teachers experience and adapt to different methodologies simultaneously. This gap in understanding makes it difficult to optimize the integration of various teaching approaches and provide appropriate guidance to teachers (Richardson & Park, 2023).

Purpose of the Study

This comprehensive research study aims to investigate and analyze the complex dynamics of teacher perceptions and experiences regarding the implementation of Traditional Lessons, Eko Excel, and the Unified Lesson Plan in Lagos State schools.

Research Questions

This study seeks to address three primary research questions that will guide the investigation of teacher perceptions and experiences regarding different teaching approaches in Lagos State schools:

1. To what extent do Lagos State primary school teachers perceive the effectiveness of the Unified Lesson Plan compared to Traditional Lessons and Eko Excel in their teaching practice?
2. What are the resource and time management challenges teachers encounter when implementing the three methods in Lagos State primary schools?
3. How do infrastructure and technological reliability issues influence teachers' experiences with different teaching methodologies in Lagos State primary schools?

Literature Review

Educational transformation represents a critical endeavour in developing nations, with profound implications for societal progress and economic development. In Nigeria, particularly Lagos State, this journey of educational evolution reflects a complex interplay of historical legacies, technological innovations, and local contextual dynamics (Darling-Hammond et al., 2020).

Traditional teaching methodologies in Lagos State have long been characterized by deeply entrenched pedagogical practices inherited from colonial educational systems and indigenous teaching traditions. These approaches typically emphasized teacher-centred instruction, characterized by lecture-style delivery, rote learning, and standardized assessment techniques. Johnson and Smith (2022) critically examined these methods, revealing significant limitations in developing students' critical thinking capabilities and fostering meaningful student engagement.

The emergence of technology-enhanced learning marks a transformative paradigm shift in educational practices. This pedagogical revolution encompasses more than mere technological integration; it represents a fundamental reimagining of instructional approaches. Researchers like Thompson et al. (2023) have documented the multifaceted nature of this transformation, highlighting the potential of digital tools to create more interactive, personalized, and adaptive learning environments.

The Eko Excel initiative in Lagos State exemplifies this technological educational innovation. By equipping teachers with tablets containing pre-loaded content, lesson plans, and assessment tools, the program seeks to transcend traditional pedagogical boundaries. Anderson and Williams (2023) argue that such initiatives represent more than technological upgrades; they constitute comprehensive attempts to reshape the entire teaching and learning experience.

Theoretical Framework

The theoretical framework for this study is constructed upon multiple complementary theories that collectively provide a comprehensive lens through which to examine teacher perceptions and experiences with different teaching approaches. This framework integrates established educational theories with contemporary perspectives on educational change and technology integration.

Rogers' Diffusion of Innovation Theory (2003) serves as a primary theoretical foundation for this study. This theory provides a structured framework for understanding how teachers adopt and adapt to new teaching approaches, particularly in the context of Eko Excel and the Unified Lesson Plan. Rogers' theory identifies five stages in the innovation adoption process: knowledge, persuasion, decision, implementation, and confirmation. These stages align closely with teachers' experiences as they encounter and integrate new teaching methodologies into their practice. The theory also highlights the importance of innovation characteristics such as relative advantage, compatibility, complexity, trialability, and observability, which directly influence teachers' acceptance and implementation of new teaching approaches (Bubune, 2023).

Complementing Rogers' theory, Bandura's Self-Efficacy Theory (1997) provides crucial insights into how teachers' beliefs about their capabilities influence their implementation of different teaching approaches. This theoretical perspective is particularly relevant because teacher self-efficacy has been shown to significantly impact their willingness to adopt new teaching methodologies and persist through implementation challenges. Bandura's theory helps explain variations in teacher performance and adaptation to new methodologies based on their perceived self-efficacy, mastery experiences, vicarious experiences, social persuasion, and emotional states (Thompson & Garcia, 2024). The study also draws upon Vygotsky's Sociocultural Theory of Learning (1978), which emphasizes the importance of social and cultural contexts in learning and development. This theoretical perspective is crucial for understanding how teachers' cultural contexts and social interactions influence their perceptions and experiences with different teaching approaches. Vygotsky's concept of the Zone of Proximal Development provides a useful framework for examining how teachers scaffold their own learning and adaptation to new teaching strategies (Morady-Moghaddam & Parsaiyan, 2024).

These theoretical perspectives are integrated to create a comprehensive framework that acknowledges the multiple dimensions of teacher experiences with different teaching approaches. The framework recognizes that teacher perceptions and experiences are shaped by individual factors (self-efficacy, professional identity), organizational factors (school context, resources), and systemic factors (policy environment, cultural context).

Methodology

This study employed a mixed-methods research design, combining quantitative and qualitative approaches to provide a comprehensive understanding of teacher perceptions and experiences. The mixed-methods approach was particularly appropriate for this study as it allowed for both breadth and depth in examining teacher experiences with different teaching approaches (Creswell, et al., 2023). The quantitative component, implemented through a survey, provided broad insights into patterns and trends across a large sample of teachers, while the qualitative component, conducted through focus group discussions, offered rich, detailed perspectives on teacher experiences. The study population comprised all public primary school teachers in Lagos State, Nigeria. This population was chosen because these teachers have had direct experience implementing Traditional Lessons, Eko Excel, and the Unified Lesson Plan in their daily teaching practice. The focus on public primary school teachers ensured that all participants had exposure to the standardized teaching approaches being investigated.

A multistage sampling technique was employed to select participants for the study. This sampling approach was chosen for its effectiveness in handling large, geographically dispersed populations while maintaining representativeness (Thompson et al., 2023). The sampling process proceeded through the following stages:
Stage 1: Selection of Local Government Education Authority Badagry Local Government Education Authority was selected from among Lagos State's education authorities. This selection considered factors such as accessibility, representation of both urban and rural school contexts, and the presence of schools implementing all three teaching approaches.
Stage 2: Selection of Schools Within the Badagry Local Government Education Authority, schools were stratified based on factors such as location (urban/rural), size, and duration of implementing different teaching approaches. This stratification ensured representation across different school contexts.
Stage 3: All teaching staff in all schools under Badagry Local Government Education Authority were selected., 758 teachers were identified for participation in the quantitative phase of the study. The sample size was determined using Krejcie and Morgan's (1970) table for determining sample size from a given population, with consideration for potential non-response. Of the 758 teachers invited to participate in the survey, 566 completed and returned valid questionnaires, representing a response rate of 74.7%. This response rate exceeds the 70% threshold recommended for survey research in educational settings (Anderson & Williams, 2023), suggesting adequate representation of the target population. For the qualitative phase, 15 teachers were randomly selected from primary schools in Badagry to participate in focus group discussions. The selection of focus group participants ensured representation across different grade levels, years of teaching experience, and exposure to different teaching approaches.

Research Instruments
Two primary instruments were used for data collection:

1. Teacher Perception and Experience Questionnaire (TPEQ) The TPEQ was developed specifically for this study based on extensive literature review and expert consultation. The questionnaire consisted of four sections:

- Section A: Demographic Information, Section B: Perceptions of Teaching Approaches (5-point Likert scale), Section C: Implementation Experiences (5-point Likert scale) and Section D: Challenges and Opportunities (open-ended questions)

The instrument was validated through expert review and pilot testing. Cronbach's alpha coefficient was used to establish reliability, with values ranging from 0.78 to 0.89 for different subscales, indicating good internal consistency.

2. Focus Group Discussion Guide A semi-structured focus group discussion guide was developed to explore teachers' experiences in greater depth. The guide included open-ended questions focusing on:

- Detailed experiences with each teaching approach
- Perceived benefits and challenges
- Integration strategies
- Support needs and recommendations

Data Collection Procedure

The data collection process was conducted in two phases:

Phase 1: Quantitative Data Collection

- Necessary permissions were obtained from relevant authorities
- Research assistants were trained in questionnaire administration
- Questionnaires were distributed to selected schools
- Follow-up visits were conducted to ensure adequate response rates

Phase 2: Qualitative Data Collection

- Two focus group sessions were conducted with 7-8 teachers each
- Sessions were audio-recorded with participant consent
- Each session lasted approximately 90 minutes
- Professional moderators facilitated the discussions

Data Analysis

The study employed both quantitative and qualitative data analysis techniques:

Quantitative Analysis:

- Descriptive statistics (means, standard deviations, frequencies)
- Inferential statistics (chi-square tests, t-tests, ANOVA)
- Factor analysis for identifying underlying patterns
- Statistical Package for Social Sciences (SPSS) version 26 was used

Qualitative Analysis:

- Thematic analysis of focus group transcripts
- Coding using NVivo software
- Development of themes and subthemes
- Integration of quantitative and qualitative findings

Results

Research Question 1: To what extent do Lagos State primary school teachers perceive the effectiveness of the Unified Lesson Plan compared to Traditional Lessons and Eko Excel in their teaching practice?

Table1: Comparative Analysis of Teaching Methodologies

Methodology	Preference (N)	Preference (%)	Perceived Effectiveness (N)	Perceived Effectiveness (%)
Unified Lesson Plan	354	62.5%	392	69.3%
Eko Excel	156	27.6%	132	23.3%
Traditional Method	56	9.9%	42	7.4%

The study revealed a clear hierarchical preference among teachers. Unified Lesson Plan emerged as the most preferred methodology, with 62.5% of teachers selecting it as their most preferred approach. Eko Excel ranked second, preferred by 27.6% of teachers, particularly among younger and more technologically inclined educators. The Traditional Method was the least preferred with only 9.9% maintaining preference for this method. This finding was corroborated by focus group discussions, where participants frequently cited the structured yet flexible nature of the Unified Lesson Plan as its primary advantage. As one focus group participant noted: "The Unified Lesson Plan gives us a clear framework while still allowing us to adapt to our pupils' needs."

Research Question 2: What are the challenges teachers encounter when implementing the three methods in Lagos State primary schools?

Table 2: Implementation Challenges by Methodologies

Challenge Type	Unified Lesson Plan (%)	Eko Excel (%)	Traditional Method (%)
Time Consumption	22.5%	68.2%	76.3%
Resource Cost	18.7%	62.4%	71.2%
Preparation Difficulty	24.1%	22%	73.5%

According to the findings shown on Table 2, Eko Excel and Traditional Method showed higher time and resource management challenges. Unified Lesson Plan and Traditional Method showed higher preparation challenge. Analysis of focus group discussions provided deeper insights into these concerns. Teachers frequently mentioned the financial burden of buying different textbooks to write lesson notes in the Traditional Method. They also expressed concern on the huge investment the Lagos State Government must have made to purchase thousands of tablets for the Eko Excel programme. One participant said: "When the tablets malfunction, we often wait weeks for repairs or replacements, which disrupts our teaching schedule significantly."

Research Question 3: How do infrastructure and technological reliability issues influence teachers' experiences with different teaching methodologies in Lagos State primary schools?

Table 3: Technological Issues Across Methodologies

Technical Challenge	Unified Lesson Plan (%)	Eko Excel (%)	Traditional Method (%)
System Breakdowns	3%	76.4%	N/A
Connection Issues	15.2%	68.7%	N/A
Device Maintenance	18.5%	72.6%	N/A

None of the identified technical challenge was applicable to the traditional method approach. 76.4% of teachers experienced system breakdowns with Eko Excel. The Unified Lesson Plan demonstrated superior technological reliability. 72% reported significant maintenance challenge with Eko Excel.

Discussion of Findings

The research reveals a complex landscape of teaching methodologies in Lagos State primary schools, providing critical insights into the intricate process of educational transformation. The findings contribute significantly to our understanding of educational reform implementation, particularly in developing contexts. The Unified Lesson Plan emerged as the most preferred and effective methodology, with 62.5% of teachers selecting it as their primary approach. This preference aligns with previous research by Darling-Hammond et al. (2020), which emphasizes the importance of structured yet flexible pedagogical frameworks. The plan's success can be attributed to its ability to provide clear guidance while maintaining teacher autonomy, a critical factor in successful educational innovation. Comparative analysis of implementation challenges revealed nuanced insights into the practical realities of different teaching methodologies. The Traditional Method and Eko Excel demonstrated significantly higher challenges in time consumption and resource management. These findings resonate with Wilson and Kumar's (2023) research on educational reforms in developing contexts, which highlighted the substantial resource constraints faced by educators. Technological reliability emerged as a critical differentiator among methodologies. Eko Excel experienced substantial technical challenges, with 76.4% of teachers reporting system breakdowns and 68.7% experiencing connection issues. This aligns with Thompson and Garcia's (2024) research on technological integration in education, which emphasized the importance of robust technological infrastructure in educational innovations.

The study's findings provide empirical support for Rogers' Diffusion of Innovation Theory, illustrating the complex process of technological and methodological adoption. The varying levels of teacher preference and perceived effectiveness reflect the multifaceted nature of educational innovation adoption, as outlined by Anderson and Williams (2023). This perspective underscores that successful educational transformation extends beyond technological implementation, requiring a comprehensive approach that considers teacher experiences, professional development, and contextual adaptability. Focus group discussions revealed the human dimension of methodological transitions. Teachers articulated not just technical challenges but also emotional and professional considerations. This aligns with Bandura's Self-Efficacy Theory, which emphasizes the critical role of ones' beliefs and perceived capabilities in implementing educational innovations (Bhati & Sethy, 2022).

The socioeconomic and cultural context emerged as significant moderating variables. Oyewole and Adebayo (2023) similarly emphasized the importance of local context in educational reforms. The diverse educational landscape of Lagos State demonstrates that implementation strategies must be flexible, recognizing variations in resource availability, technological access, and community expectations. Comparative studies provide additional context to these findings. Roberts and Chen's (2023) research on educational reform implementation similarly highlighted the challenges of integrating multiple teaching methodologies. The current study extends this understanding by providing a detailed examination of teachers' perceptions and experiences in a specific local context. The technological challenges encountered with Eko Excel raise important questions about the readiness of educational infrastructure in developing contexts. Johnson and Smith's (2022) research on technological integration in education supports these findings, emphasizing the need for comprehensive support systems and infrastructure development.

Conclusion

The research provides a comprehensive exploration of teaching methodologies in Lagos State primary schools, revealing the complex landscape of educational transformation. Our investigation into the implementation of Traditional Lessons, Eko Excel, and the Unified Lesson Plan offers critical insights into the multifaceted challenges and opportunities of educational reform. The findings demonstrate that educational transformation is not a linear process but a dynamic interaction between technological innovation, pedagogical approaches, and teacher experiences. The Unified Lesson Plan emerged as the most promising methodology, highlighting the importance of structured yet flexible educational frameworks that respect teachers' professional judgment and adaptability.

Recommendations

The research strongly recommends comprehensive professional development programmes that provides targeted training on technological integration for teachers and enhance teachers' technological self-efficacy and adaptability.
Also, given promising results of Lagos SUBEB Unified Lesson Plan, continuous reforms should be done based on teacher feedback to improve the approach.

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UNIVERSITY-TO-WORKPLACE READINESS: EVALUATING 21ST-CENTURY COMPETENCIES AMONG FRESH GRADUATES IN A NIGERIAN UNIVERSITY

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Abstract
In today's dynamic and highly competitive global economy, the possession of 21st-century work-ready skills is critical for graduates' employability and national development. This study investigated the level of awareness and possession of these essential competencies such as communication, critical thinking, collaboration, adaptability, and digital literacy among fresh graduates of Olabisi Onabanjo University, Nigeria. Grounded in Human Capital Theory and Skills Mismatch Theory, the study employed a descriptive survey design with a stratified random sample of 109 respondents. Data were collected using a validated questionnaire and analyzed using descriptive and inferential statistics. Findings revealed that while graduates displayed high awareness and proficiency in communication, digital literacy, and creativity, significant gaps persisted in problem-solving, teamwork, crital thinking and aspects of leadership. Graduates expressed mixed perceptions about the university's effectiveness in preparing them for the workplace. The study concludes that curriculum reforms, experiential learning opportunities, and targeted faculty development are imperative to bridge identified gaps. Recommendations include embedding practical, skill-based modules into academic programs, strengthening internship schemes, and fostering a culture of continuous feedback on employability skills. These measures are essential to ensure that graduates are not only academically qualified but also equipped with the competencies required for success in a rapidly evolving labour market.

Keywords: 21st-century skills, Graduate employability, Nigerian higher education, Skills gap, Work-ready competencies.

Introduction
The transition from university education to the workforce represents a critical juncture in the professional development of young graduates. The pressure on Nigerian universities to produce graduates who are not only academically qualified but also workplace-ready has intensified over the past decade. In recent years, the emphasis has shifted from merely obtaining academic qualifications to acquiring a more holistic set of competencies that align with the evolving demands of the 21st-century workplace. With the dynamic nature of today's job market, graduates are expected to demonstrate a wide range of competencies, especially 21st-century skills such as critical thinking, communication, collaboration, digital fluency, and adaptability (OECD, 2019). While Nigerian universities continue to produce a large number of graduates annually, there is increasing concern that many of these graduates lack the requisite skills for immediate employability (Soule & Warrick, 2015) and the rate of youth unemployment and underemployment remains troubling—a sign that academic credentials alone are no longer sufficient indicators of employability (Feraco et al., 2022).The reality of today's job market is that employers are no longer satisfied with technical knowledge alone; they seek individuals who can think critically, adapt quickly, communicate effectively, and work collaboratively in diverse environments (Scott, 2015). Olabisi Onabanjo University (OOU), like many Nigerian tertiary institutions, has made efforts to integrate practical experiences and skill development into its curriculum. However, questions persist regarding the effectiveness of these initiatives. This study investigates the extent to which

fresh graduates of OOU are aware of and possess 21st-century work-ready skills, It also evaluates the extent to which university education fosters these competencies and how well the university is equipping them to meet the expectations of the modern labor market, proposing strategies to bridge the existing skill gaps. The study is anchored on Human Capital Theory and Skills Mismatch Theory, which together offer a multidimensional lens for analyzing graduate readiness in the contemporary labor market.

Literature Review

Globally, the demand for graduates who can operate in multidisciplinary, technologically advanced, and collaborative work environments has grown exponentially (UNESCO, 2023). Studies have consistently highlighted the gap between higher education outputs and workplace requirements. A recent study by Feraco et al. (2022) found that employers in emerging economies, including Nigeria, frequently cite deficiencies in problem-solving, collaboration, and adaptability as critical concerns. 21st-century skills are now central to employability discourses, particularly in low- and middle-income countries where digital transformation and labor market disruption are reshaping work environments (ILO, 2021). The discourse on 21st-century skills encompasses a broad array of competencies considered essential for personal and professional success in the digital age. According to the OECD (2019), these skills include cognitive abilities such as critical thinking and problem-solving, socio-emotional competencies like communication and teamwork, and technical proficiencies in digital literacy and information management. Scott (2015) defines 21st-century skills as the knowledge, skills, and attitudes needed to navigate a rapidly changing global society and economy. To Cohen et al., (2017) these are competencies that individuals in the Information Age must continuously develop to remain competent and qualified. Hamarat, (2019) emphasize that these skills are no longer optional but fundamental for individuals aiming to remain relevant in their careers.

Studies by the OECD (2019) and others (Feraco et al., 2022; Ferreira & Robertson, 2022; Ramos et al., 2023) emphasize that socio-emotional and cognitive skills, such as critical thinking and empathy, will become key in the future, alongside the evolution of more technical skills. Noting that employers now demand more from graduates, seeking individuals ready to adapt to the work environment, think critically about complex problems and collaborative effectively with diverse teams in the organization. Despite the growing emphasis on the significance of 21st-century work-ready skills, concerns persist about the lack of preparation among first-time employees, particularly graduates, in demonstrating these skills in the workplace.

In Nigeria, the conversation around graduate employability has gained traction, particularly in the context of youth unemployment and underemployment, this has become a recurrent theme in education policy and academic discourse. Studies by Pitan (2016) and and Okolie et al. (2020) reveal a growing disconnect between university curricula and labor market demands. This disconnect is often attributed to rigid academic structures, outdated curricula, limited industry-academic collaboration, lack of experiential learning opportunities and a lack of emphasis on soft skills development. Similarly, a survey conducted in Ogun State highlighted that while many graduates possess domain-specific knowledge, their generic and innovative skills fall short of employer expectations. Graduates report familiarity with these skills but demonstrate varying degrees of mastery. For example, while communication and digital literacy are often rated high, competencies such as leadership, teamwork, and real-world problem-solving tend to lag behind. (Olanipekun, 2018).

While technical knowledge remains important, the workplace increasingly values graduates who can demonstrate adaptability, innovation, and interpersonal acumen (Feraco et al., 2022). While institutions like OOU have incorporated SIWES and entrepreneurship education into their programs, gaps remain in students’ abilities to demonstrate transferable skills during job applications and in the workplace. This aligns with national studies that associate these gaps with limited opportunities for applied learning and student engagement in cross-functional activities (Ramos et al., 2023). The problem is exacerbated by limited exposure to skill-building opportunities such as internships, mentorships, and collaborative learning environments. Another dimension is students' own awareness—or lack thereof—about the importance of acquiring such competencies during their university education. Curriculum reform has been proposed as a vital step in equipping students with practical and transferable skills. Cavanagh, Burstone, and Southcombe (2015) advocate for integrating employability skills into course content through experiential learning, project-based tasks, and real-world problem-solving activities. Moreover, internship programs and industry partnerships offer students hands-on exposure to workplace expectations, helping them internalize and apply theoretical knowledge.

This study is firmly rooted in Human Capital Theory, which emphasizes that investments in education and skill development enhance individual productivity and societal growth. In the context of this research, the acquisition of 21st-century skills—like communication, problem-solving, and digital literacy—represents the kind of human capital that increases a graduate’s value in the labor market (Becker, 1994; Muo, 2016). By assessing how well Olabisi Onabanjo University prepares its students with these competencies, the study reflects on how higher education contributes to economic productivity and individual success. Simultaneously, Skills Mismatch Theory provides a critical lens for examining the disconnect between the skills employers need and what graduates actually possess. This mismatch has been cited as a major contributor to youth underemployment and stagnating productivity levels, particularly in Nigeria (Muo, 2016; Zimmermann & Saint-Paul, 2016). Together, these theories not only justify the focus of this research but also underscore the need to redesign curricula that bridge the gap between academic training and workplace realities. This study aims to investigate the level of awareness and possession of essential 21st century work-ready skills among recent graduates of Olabisi Onabanjo University, evaluate the effectiveness of current awareness initiatives, and suggest strategies for addressing the skill development gap.

Objective of the study

The aim of this research is to;

1. Assess the level of awareness among recent graduates of OOU regarding the skills and competencies deemed crucial for success in the 21st-century workplace.
2. Ascertain if the fresh graduates of OOU possesses the 2st century work-ready skills
3. Examine students' perception of the effectiveness of the University's efforts to prepare them for the 21st-century workplace.
4. Determine areas where students may need more support in developing 21st century work skills.

Research questions

1. What is the level of awareness among recent graduates of Olabisi Onabanjo University regarding the essential skills and competencies required for success in the 21st-century workplace?

2. To what extent do fresh graduates of Olabisi Onabanjo University possess the work-ready skills aligned with 21st-century workplace demands?
3. How do students perceive the effectiveness of Olabisi Onabanjo University's efforts in preparing them for the 21st-century workforce?
4. In which specific skill areas do students at Olabisi Onabanjo University require further support to meet the expectations of the 21st-century labor market?

Methodology

The study uses a descriptive survey design to examine the awareness and possession of 21st-century work-ready skills among recent graduates of Olabisi Onabanjo University. Population of the study include the fresh graduates of Olabisi Onabanjo University, students who had recently graduated from the university and where yet to be employed. Stratified sampling based on faculty and random sampling were techniques to draw an unbiased sample of 109 graduates.

The instrument for data collection 'The awareness and possession of 21" century work skill'was a 4 scale Likert questionnaire, with options SA - Strongly Agree (4 points), A - Agree (3 points), D - Disagree (2 points), SD - Strongly Disagree (1 point). The instrument was validated and was further subjected to Cronbach alpha analysis to ensure the reliability. A reliability coefficient 0.81 was gotten and considered an acceptable value. Data was collected via google form shared on the student's platform, participation was voluntary. The data collected from the completed questionnaires was analysed with the appropriate descriptive statistics.

Results

Table 1: Awareness level of 21st century skills deemed crucial for success in the 21st-century workplace.

Description	Awareness	Mean	SD
Important for success in the 21st century workplace	Overall awareness of 21st Century Work Skills	3.31	.889
	Communication skill	1.96	1.14
	Written communication	2.80	1.15
	Oral communication	2.56	.541
	Critical Thinking and problem Solving	3.46	.943
	Analytical Thinking	3.16	1.06
	Creative thinking	2.45	.441
	Digital Literacy	2.17	.888
	Proficiency in using Office Software, such as Microsoft suites	2.63	.816
	Ability to use digital tools for collaborations and communication	2.44	.433
	Teamwork and collaboration	2.23	1.18

Description	Awareness	Mean	SD
	Ability to work effectively in a Team	1.75	1.02
	Ability to resolve conflicts and negotiate with others	2.53	.336
	Leadership and Management	3.46	.943
	Ability to motivate and inspire others .	3.16	1.06
	Ability to manage time and resources effectively	2.45	.441
	Your confidence as regards your 21st century work skills	3.62	.524
	Grand Mean	**2.78**	**.862**

Table 1 shows the result of the importance of the concepts of the 21st century work ready skills The results used a 2.5 criterion mean for decision (Mean >2.5). Mean obtained above this was accepted. The table shows a grand mean of 2.78 which is above the criterion mean, thus can be concluded that OOU fresh graduates indicated a high level of awareness of the importance of 21st century work ready skills for success in today's workplace. The analysis reveals that Leadership and Management skills are perceived as highly important for success in the 21st-century workplace (M = 3.46, SD = 0.943), indicating strong recognition of their relevance. Ability to motivate and inspire others is also valued (M = 3.16, SD = 1.06), though the slightly higher standard deviation suggests variability in how consistently this is acknowledged among respondents. In contrast, time and resource management, while essential in practical terms, received the lowest mean score (M = 2.45), yet with the lowest variability (SD = 0.441), reflecting a consensus that it is less central compared to interpersonal and leadership capabilities. These findings align with contemporary literature emphasizing leadership and motivation as key drivers of team performance and organizational growth in the modern workforce.

Table 2: 21st Century skills possessed by OOU fresh Graduates.

Description	Items	Mean	SD
Communication And Collaboration	I am comfortable working in a team	3.33	.821
	I collaborate a lot on group projects	2.56	.339
	I communicate with my pears regularly	2.98	1.09
	I prefer working independently	2.51	.309
Critical Thinking and Problem Solving	I approach a problem by considering different perspectives and solutions	2.65	.321

Description	Items	Mean	SD
	I evaluate different solutions to a problem before making decisions	1.44	.104
	I can solve problems on my own	1.64	.091
Creativity and Innovation	I am comfortable thinking outside the box	3.28	.710
	I can generate new and innovative ideas	3.34	.665
	I have the skills required to design or create new things	3.28	.681
Technology and Digital Literacy	I regularly use technology in my daily life	3.20	.731
	I feel confident using different software and hardware tools	3.25	.731
	I make use online collaboration tools such as Google Docs Microsoft Office,etc.	3.15	.803
Adaptability and Flexibility	I manage change and uncertainty well	3.14	.900
	I am comfortable walking in unfamiliar environments	3.26	.852
	I can adjust to new situations or tasks on short notice	3.01	.680
Leadership and Initiative	I assume leadership role in Group projects	2.97	.636
	I am comfortable taking initiatives and making decisions	2.92	.712
Learning and Self-Direction	I enjoy learning new concepts or skills	2.99	.651
	I can seek out resources and help when needed	2.94	.628

Description	Items	Mean	SD
	I can set and achieve learning goals for myself	3.13	.660
Overall Assessments	I consider myself ready for 21st century work	3.20	.641
	Grand Mean	**3.06**	**.681**

Table 2 presents the self-reported 21st-century skills of fresh graduates from Olabisi Onabanjo University (OOU), analyzed across seven core domains. The results used 2.5 criterion mean for decision mean (Mean > 2.5) The overall grand mean of 3.06 (SD = .681) suggests a moderately positive self-assessment of workplace readiness. Critical analysis of the means obtained shows that each subsection measured recorded above the criterion save for some aspect of critical thinking, which implies that the fresh graduate possess some skill levels in all the listed dimensions.

Communication and Collaboration

This domain recorded a relatively high mean score of 3.31 (SD = .889), driven by strong responses on comfort with teamwork (M = 3.33), though less confidence was observed in collaborative project engagement (M = 2.56) and peer communication (M = 2.98). The lower standard deviation on group work (SD = .339) suggests consensus in this weakness. Preference for working independently (M = 2.51) further reflects a possible area for growth in collaborative disposition.

Critical Thinking and Problem Solving

Graduates reported low proficiency in this domain (M = 2.65, SD = .321), with particularly weak responses for evaluating solutions (M = 1.44) and independent problem-solving (M = 1.64). These results highlight a critical gap in reasoning and analytical capabilities, reinforcing concerns raised in earlier studies on Nigerian graduates' employability skills deficit.

Creativity and Innovation

This domain scored highly overall (M = 3.30, SD = ~.68), with the highest individual mean from the item on idea generation (M = 3.34). These results suggest that students perceive themselves as capable of thinking innovatively and producing creative work, a crucial attribute for dynamic work environments.

Technology and Digital Literacy

Scores in this area were strong and consistent (M = 3.20–3.25, SD ~.73–.80), suggesting widespread engagement with digital tools. Confidence with software, hardware, and collaborative platforms implies an encouraging level of digital fluency among graduates, aligning with modern workplace expectations.

Adaptability and Flexibility

Graduates indicated relatively strong adaptability (M = 3.14, SD = .900), especially in navigating unfamiliar environments (M = 3.26). The ability to cope with change and uncertainty further supports their potential to thrive in dynamic, evolving work contexts.

Leadership and Initiative
This domain showed moderate strength (M = 2.97–2.92), suggesting that while students may be willing to take initiative, actual engagement in leadership roles remains limited. These results imply the need for more experiential leadership training during university programs.

Learning and Self-direction
Students reported a fairly positive orientation toward lifelong learning (M = 2.99), goal setting (M = 3.13), and resource-seeking behavior (M = 2.94), reflecting a self-motivated approach to personal and professional development.

Overall Self-Assessment
Respondents' perception of their readiness for 21st-century work was notably positive (M = 3.20, SD =.641), reinforcing general confidence. However, the discrepancies across domains—particularly in critical thinking and collaboration—suggest that while they may feel ready, certain skill gaps persist that could hinder workplace integration.

Table 3: University's Effort at Preparing Fresh Graduates for the 21st Century Workplace

Description	Item	Mean	Std
The extent to which the university has prepared you			
	Communicating effectively in the workplace	2.56	.644
	Written communication	3.24	.621
	Oral communication	3.23	.631
	Critical Thinking and problem Solving	1.62	.799
	Analytical Thinking	3.17	.402
	Creative thinking	2.19	.439
	Digital Literacy	1.63	.859
	Proficiency in using Office Software, such as Microsoft suites	3.69	.591
	Ability to use digital tools for collaborations and communication	3.68	.647
	Teamwork and collaboration.	3.40	.760

Description	Item	Mean	Std
	Ability to work effectively as a Team.	1.55	.868
	Ability to resolve conflicts and negotiate with others.	3.32	.554
	Leadership and Management.	2.93	.658
	Ability to motivate and inspire others .	3.06	.684
	Ability to manage time and resources effectively.	2.70	.840
	Your readiness for 21st century work skills	3.62	.524
	Grand Mean	**2.69**	**.724**

The analysis of Table 3 provides insight into how well Olabisi Onabanjo University (OOU) graduates perceive their university preparation for 21st-century workplace demands. The overall grand mean score of 2.69 (SD = .724) reflects a moderate level of confidence in the university's effectiveness in equipping them with contemporary employability skills.

Communication Skills

Graduates expressed a fair level of confidence in their written (M = 3.24) and oral communication abilities (M = 3.23), yet rated their general workplace communication competence lower (M = 2.56). This suggests that while technical communication skills may have been adequately addressed, real-world application remains an area for improvement.

Cognitive and Problem-Solving Skills

Notably low scores were observed in critical thinking and problem solving (M = 1.62, SD = .799) and creative thinking (M = 2.19). While analytical thinking received a relatively higher rating (M = 3.17), these findings point to a pressing need for pedagogical strategies that cultivate deeper intellectual engagement and innovation—an issue echoed across studies on graduate employability gaps

Digital Competence

A sharp contrast emerged in the digital literacy domain. While general digital literacy was rated poorly (M = 1.63), proficiency in specific software tools like Microsoft Office (M = 3.69) and digital collaboration platforms (M = 3.68) received high marks. This may suggest that digital skill training is skewed toward tool use rather than conceptual understanding or adaptability to broader tech ecosystems.

Teamwork and Leadership

Although teamwork and collaboration scored well (M = 3.40), the low mean for ability to work effectively as a team member (M = 1.55) indicates a potential mismatch between perceived group involvement and functional collaboration skills. Leadership abilities were moderately rated (M = 2.93), suggesting that while some effort is made to encourage initiative, further structured opportunities for leadership practice are needed.

Readiness for Work

The item on overall readiness for 21st-century work skills was one of the highest rated (M = 3.62), reflecting a general sense of preparedness despite specific gaps. Skills like conflict resolution (M = 3.32) and motivation/inspiration (M = 3.06) were also perceived positively, indicating an emerging awareness of soft skills in workplace dynamics.

Discussion

The findings highlight a nuanced understanding of the 21st-century skills possessed by graduates of Olabisi Onabanjo University (OOU) and the extent to which the university has prepared them for the demands of today’s dynamic workplace. With a grand mean of 3.06 for self-assessed skill possession and 2.69 for perceived university preparedness, there is a moderate alignment, yet clear evidence of skill gaps. Communication skills—especially written and oral—received high ratings, suggesting that traditional aspects of communication are adequately addressed. However, general workplace communication scored lower, indicating a potential mismatch between academic training and workplace expectations. This gap mirrors findings by Aina et al. (2023), who argued that graduates often lack the contextual communication agility required in corporate settings.
In the area of digital literacy, graduates rated themselves highly in the use of tools like Microsoft Office and online collaboration platforms, but poorly in general digital literacy. This discrepancy may suggest surface-level tool proficiency without deeper digital fluency—a trend also noted by Ajadi and Salami (2024), who emphasized that digital readiness must go beyond operational skills to include adaptability, safety, and data literacy.

The most concerning gap appeared in critical thinking and problem-solving, with very low ratings (M = 1.62 in Table 3; M = 2.65 in Table 2). This supports recent concerns raised in the literature that university curricula are still largely content-heavy and assessment-driven, leaving little room for problem-based or inquiry-based learning (Bakare et al., 2022; Obaje et al., 2023). While analytical thinking was rated more positively, the disconnect between critical reflection and real-time decision-making capabilities is evident.

Interestingly, creativity and innovation, as well as teamwork and collaboration, were moderately strong areas, particularly in personal assessments. Graduates feel relatively confident generating new ideas and working with others, aligning with the growing emphasis on soft skills and collaborative intelligence in the era of digital transformation (Nguyen & Hoang, 2023).
Leadership and initiative, as well as self-direction, showed middle-range scores, suggesting that graduates may be willing but not always equipped or empowered to lead or set independent learning goals. As Industry 4.0 evolves into Industry 5.0, the need for graduates who can take initiative, adapt swiftly, and manage uncertainty has become even more urgent (Sari et al., 2022).
In summary, while OOU graduates show strength in technical and operational tools and feel generally confident about entering the workforce, the university appears to fall short in nurturing critical, creative, and collaborative thinking. Bridging these skill gaps requires a deliberate

rethinking of curriculum design, experiential learning, and assessment frameworks aligned with real-world complexity and global employability standards.

Conclusion

This study underscores the urgent need to rethink how universities in Nigeria, prepare students for the future of work. The findings affirm the pressing need for Nigerian universities, including Olabisi Onabanjo University, to go beyond academic instruction and deliberately cultivate 21st-century work-ready skills among students. Awareness alone is insufficient—structured programs, curriculum enhancements, and partnerships with industry are necessary to translate awareness into competence. Equipping graduates with these skills is not only vital for their individual success but also crucial for national development in an increasingly competitive and technologically driven world. The study therefore proposes these appropriate and actionable recommendations to strengthen university-to-workplace readiness through 21st-century skills development:

1. Integrate 21st-century skills into curriculum design by embedding competencies like critical thinking, creativity, collaboration, and digital fluency across all disciplines through project-based learning and interdisciplinary assessments
2. Train faculty on pedagogical strategies that foster these skills—such as inquiry-based learning, flipped classrooms, and real-world simulations—to ensure consistent delivery across departments
3. Establish university-industry collaborations to align academic outcomes with labor market needs through internships, mentorships, and guest lectures from employers
4. Promote co-curricular engagement (e.g., debates, hackathons, community service) as platforms for practicing soft skills like leadership, communication, and adaptability
5. Assess and track students' 21st-century skills using tools and feedback mechanisms to help them reflect and improve on these essential competencies.

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EDUTECHPRENEURSHIP: PHOTOCOPY AND VIDEO PRODUCTION AS VERITABLE SOURCES OF INCOME IN THE WORKPLACE

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Abstract

Educational Technology can be seen as a systematic approach, which is a self-adjusting combination of interacting with people, and the equipment so designed by man to accomplish some predetermined objective. Entrepreneurial education is designed to teach the skills and knowledge that is needed to be known before embarking on a new business venture. The training in entrepreneurial education may initially be perceived as a cost in terms of time and money but it would eventually be appreciated. Photocopy is a print media, a visual medium, and digital document creation. The machine used in making photocopies is referred to as a photocopier. A photocopier can be referred to as electronic duplication that focuses on a reproduced image on plain bond paper. It uses scientific knowledge to function. Video production encapsulates all that comes with an idea for a show, film, or event as it gets to the final product in the consumer's hands. Video production entails a lot of activities. What is seen on the television or film screen is the end product of video production work. Video production is also called videography. Photocopy and Video Production are part of the course contents taught in Educational Technology in Colleges of Education which when best learnt become entrepreneurial skills forming a source of income. This paper therefore seeks to examine photocopy and video production as learning experiences that learners are exposed to under educational technology as skills which if effectively and efficiently acquired can form entrepreneurial skills. How this serves as a source in the workplace will also be examined. Photocopy and video production, if well learnt and practiced can be regarded as a sustainable source of income in the workplace. It can be suggested to the stakeholders that photocopy and video production be taken as forming part of the entrepreneurial skills.

Keywords: Photocopy, video production, educational technology, entrepreneurship and workplace.

Introduction

The National Policy on Education is definite that the defining character of an educated person is the competence to live and work successfully in society. According to Olawoye, (2008), the proof of being educated is provided by possession of these competencies. Individuals who lack life skills and competencies are prone to suffer identity crises and social disorientation. He further stated that, the curriculum at each stage of formal education, from primary to tertiary, is therefore geared towards inculcating civilized and enlightened mode of living as well as competencies. Even the federal government devoted ₦210 bn or 13 percent of the total budget for 2008 education alone, apart from another ₦39.7bn earmarked as intervention fund for the Universal Basic Education Programme. The education budget 2008 represents about 12 percent increase over the 2007 ₦188bn (Owoseni, 2011).

We learn from our experience and this is why we can withstand the "shock" of learning from nature. A lot of man's activities emanate from his ability to think, acquire knowledge and use his natural experiences and native intelligence to solve the problems that confront him daily.

Therefore, when you can devise solution to a given problem through the thought process, you have invariably applied technology. Technology has made the approach to the giving and receiving instruction easy through the utilization of various media. It is however worth remembering that the human element in all educational processes is primary, while the technical element is in almost all cases secondary (Adeyanju, 2013). This being the case, good teaching and effective learning are parts and parcel of human professional role. Simply put, the thought of how media can assist in the teaching and learning process is technology on its own. Similarly, the development of selected media for doing the actual teaching such that the desired learners' outcomes are achieved is educational technology.

The term technology simply describes the expert application of scientific knowledge in problem solving. It is also referred to as the technique or method of doing something expertly. Educational Technology is concerned with the problem of an educational context, and it is characterized by its disciplined approach to a creative organization of resources for learning. Educational technology is also concerned with the effective utilization of resources, equipment and materials, which are essential for the purpose of improving teaching and learning processes. The equipment and materials, which may be hardware and software are mostly used by technologists for adequate enhancement of teaching and learning in and out of school (Adeyanju, 2013).
Educational technology is defined as media borne out of communication revolution that the teacher uses for instructional purposes including the use of gadgets. Ogunranti (1982) in Adeyanju (2013), sees it as principles and methods which bring together men and resources in an effort to effectively find solution to educational problems. Educational technology is a term used to describe a variety of material and devices designed to provide educators with component parts of a system that will enable them to communicate more effectively with students and that will facilitate student learning.

Education remains a vital transformational tool and formidable instrument for socio-economic empowerment, wealth creation, and employment generation, poverty alleviation and value orientation which government has talked about for so long now. Suffice it to be mentioned that education, training and experience can increase the supply of entrepreneurs by making available more skills which are suitable for entrepreneurial endeavour. Entrepreneurship education involves the willingness of people to persistently pursue the opportunity to create wealth. This is done through innovative creation of products or services that will meet customers' needs, using judicious resources in a way that results in the growth of enterprise which satisfies the expectations of stakeholders. Business education in Nigeria should emphasize entrepreneurship consciousness for it to be relevant in achieving the right type of value and attitudes for the survival of the individual and the Nigeria society. Having been successfully equipped with entrepreneurial skills through persistent education, one is ready to contribute positively to reducing unemployment by being self-employed. Entrepreneurship education stands out to be an antidote to unemployment having worked in line with today's educational policies that highlight self-reliance, self-employment, gainful employment and consistent with global awareness. Entrepreneurship education enhances the acquisition of necessary skills for gain and self-employment. (Abiola and Ibitoye, 2023).

The National Economic Empowerment and Development Strategy (2004) document lends credence to the place of education by clearly explaining its role in self-reliance and development, Abiola and Ibitoye (2023) also supports this when they asserted that the goals of wealth creation or generation, poverty reduction and value re-orientation can only be attained and sustained through an efficient education system which impacts the relevant skills, knowledge, capacities,

attitudes and values. In view of the benefits of education enumerated above, Nigeria has provided education for decades with abundant available manpower. However, what keeps agitating the nation endlessly borders on the slow and inefficient economy, near primitive democracy and violent social co-existence in society (NEEDS, 2004).
Adeyanju (2013) citing Buskirk (1976) stated that education can be used to attain self-reliance and poverty eradication in African, as the true source of power in the world has not been the armies and not certainly diplomacy, but rather productive and qualitative education. President Lyndon Johnson of America officially launched a war against poverty in 1964 using education as the main weapon which he referred to as a worthwhile investment to harness his country's natural resources and the skills or potentialities of the people. In his message to congress, Johnson stated that the young man and woman who grows up without a decent education is often trapped in a life of poverty. Ojebode (2004) highlighting the above points noted that:
A person (young or old) without a decent education is trapped in life of poverty as he would not have the necessary skills for survival in a complex society.
Lack of qualitative education is a severe handicap that cripples a person as it breeds poverty which, in turn breeds despair, anger or lack of interest in anything except ones own worries.
Functional education is the only means through which people can develop their skills, capacities or potentialities.
Education is an investment that enriches the lives of the citizens and has a very high long rate of returns to the national economy.

Presently in Nigeria, the fundamental function of formal education is to produce a knowledge-based work force for national development. In this regard, the National policy on Education is definite that the defining character of an educated person is the competence to live and work successfully in society. It was observed in 2003-2008 Rolling Plans that Nigeria is currently faced with high rate of unemployment, underemployment, low productivity rising skill flight, depreciating real household income and the like. Over 70% of the unemployed in Nigeria are youths within 15-25 years of age (UNESCO, 2008). The unemployment rate of Nigerian university graduates is on the increase. Many of these graduates are found roaming round the street with no pay job(s). Majority of them are underemployed. This is not only a waste of human resources, but also a potential social time bomb to the Nigeria economy. It is against the above look of the role of education, as a Veritable Determinant for the Eradication of Unemployment in Nigeria.

Entrepreneurial education is the incorporation into the student syllabus steps involved in starting a new business based on a recognized business opportunity as well as operating and maintaining that business. The belief of some people is that entrepreneurship education does not need to be taught and therefore, an entrepreneur is born to be so. It should however be noted that for one to be a successful entrepreneur, he/she needs to learn the skills (Griffin and Hammis, 2001). Entrepreneurial education is designed to teach the skills and knowledge that is needed to be known before embarking on a new business venture. This would enhance necessary identification and avoidance of many pitfalls awaiting the less well trained and vigilant contemporaries. The training in entrepreneurial education may initially be perceived as a cost in terms of time and money but it would eventually be appreciated.

Entrepreneurial education also has a general education department as well as a professional entrepreneurship development and education component in Nigerian higher institutions, which is meant for all categories of students in the institution. Thus, all higher institutions in Nigeria integrates entrepreneurship education for all students irrespective of initial course admission and expect them to start their own businesses after graduation either on vocational or professional level to alleviate poverty and join in the scheme of improving their social-economy environment in particularly and beyond for self-economic emancipation. They are also fit to work closely with Entrepreneurs with Small and Medium Enterprises (SME). This will go a long way to eradicate unemployment in Nigeria.

Copying machines have in recent years become standard equipment in most offices such as sharp copier. Repro means copy and Graphics means pictures. Therefore, the term reprography is used for all methods of reproducing copies. In other words, duplicating or reprographic process is a method whereby a master copy is prepared to obtain large number of copies. Training on the use of equipment needs to be provided for the acquisition of skills.

Photocopy and Video Production as Concepts

Copy is the reproduction of the exact copy of a material. Copier can be bought or rented. Copier is quicker than a typist and every detail on the original matter is faithfully reproduced. Important documents can be copied before being dispatched. Photocopy is the quickest solution if an extra copy is needed (Oyedeji, 2014). Reprography is simply referred to as the production of written, typewritten or drawn material or document through a variety of processes. It could be termed copying from the original or master copy, the master copy could be handwritten, typewritten or drawn. The decision of whether to duplicate or copy is usually made by determining the number of copies needed (Oladeji, Olatoregun, Ayanrinde and Lawal, 2018). Photocopy is a digital document creation which is enabled with the use of a machine called photocopier or photocopy machine. Photocopier can be used to duplicate materials, reduce and enlarge documents, make diagrams, collate sheets and make transparencies. Photocopy has instructional values which include producing educational materials in small and large qualities; producing materials quickly and cheaply; duplicating print materials as well as enlarging and reducing materials for teaching (Odusanya, and Ajibade, 2015).

Video is a communication tool that can carry the words of educators to far more individual learners than traditional face-to-face methods (Moore, 2020). Video production is a communication form that combines inputs from multiple source. Producers, writers, videographers, editors, and on-screen talent all contribute to the final message (Compesi and Gomez, 2017). When creating a video with an educational or advocacy purpose, content creators must remember that the subject-matter specialists and video production team members all contribute components of the final message (Moores, 2020).

Video allows experts to connect with a large, diverse audience on their own timetable through a variety of platforms. Video is recognised as superior to a traditional classroom in its ability to supplement speech with illustrative video, animations, and graphics, yet inferior to the classroom in its lack of interaction leading to feedback, questions, and relationship building (Jones, 1977) in Moore (2020). Video exists within a new paradigm of Digitally Mediated Learning (DML) environments. These DMLs exist as a recent evolution of distance education, allowing learners to interact through web-based applications including both customary computers and any variety of mobile devices (Lenove, 2011). This shift both allows and requires educators to adapt their programmes for life-long engagements with audiences increasingly likely to have never known life without the internet. As devices and networks continue to increase their video delivery capacity, educational planners must consider incorporating video elements lest they fall behind in a DML educational arm race.

New Enterprises for Making Ends Meet

It is the wish of every person to be successful in life. To have good success in life, a success that is outstanding, a success that is with distinction, a success that is with excellence, one has to meet certain criteria of a good success. These criteria which are factors that can be used to characterize good success, are self-fulfillment, meeting parents and family expectations, meeting the expectations of society and the nation of their citizens, making remarkable impact in life, living an exemplary life worthy of emulation and putting in place a succession that perpetuates the success (Fatubarin, 2019). To have a good success in life requires the virtue of hard work. Hard work is defined by Longman's Dictionary of Contemporary English as working with a lot of effort. Hard work is synonymous to industry which means working hard. For any industrious persons, who is working hard to achieve outstanding success with an assignment, diligence and perseverance come in as necessary virtues in achieving the goals such a person is working hard to achieve (Fatubarin, 2019).

The establishment of new enterprises requires that some entrepreneurial activities should be carried out when economic opportunity or a business idea is created or identified. It also requires that one should evaluate opportunities in order to select the most promising one(s) for exploitation; consider all the resources needed, where and when to source for them and manage the resulting enterprise. This therefore indicates that to successfully exploit economic opportunities and establish a new enterprise, an individual needs to carry out some activities. Explanations about small business establishment are carried out using one or a combination of three theoretical approaches: the nature of opportunities; the nature of entrepreneur; and the nature of the decision-making context (Dionco-Adetayo, Atanda and Muhammed, 2012).

However, Contemporary studies now concentrate on the nature of the entrepreneur as an individual and this approach had generated several important and valuable issues, such as the effect of personality traits of entrepreneurs, socio-cultural, environmental and organisational factors on entrepreneurial success. Research focused on the entrepreneur, in recent times, is due to the fact that the entrepreneur is the principal agent that brings together other factors of production (i.e land, labour, information and capital) for productive purposes. Also, entrepreneurs' activities bring about new enterprises that provide a very large proportion of innovative and valuable products and services that contribute to the way we work and live (Dionco-Adetayo, et al, 2012).

Many individuals in transitional economies may have the desire to pursue entrepreneurial ventures but are not doing so, because they are lacking in self-belief and perhaps in the desire to achieve results. Entrepreneurship is a key factor for economic development. Public, private and non-governmental organizations are taking various measures to promote entrepreneurship in different countries. World class universities and colleges have implemented various postgraduate, undergraduate and diploma courses on small business management and entrepreneurship. In a developing country like Nigeria, the role of entrepreneurship is very important because of its role in the creation of self-employment opportunities and reduction in unemployment situations (Owoseni, 2012).

Paralleled with developing interest in entrepreneurship throughout the world, Nigeria also witnessed an increasing interest in entrepreneurship fields both among her academic scholars, and among government policy makers and business leaders. In course of time, some universities and vocational training institutes in Nigeria have incorporated entrepreneurship and small business management into their curriculum such as teaching photocopy and video production in educational technology so as to provide necessary exposure for students to entrepreneurial and industrial climate of the country. For decades, unemployment rate has been increasing. Recently, the global meltdown has also increased the unemployment level all over the world. This increased unemployment rate has created lots of problems both for the public and the government, like law-and-order situation, increased crimes and many social problems. One of the most effective alternatives suggested by the economists is self-employment (Owoseni, 2012).

Self-employment or entrepreneurship has contributed immensely to the amount of output throughout the world and Nigeria is no exception. For developing economies, entrepreneurship works like an engine for economic growth, job creation and social adjustment. There have been consistent positive relationships between entrepreneurships intentions and personality traits (Owoseni, 2011). Gartner (2012) says that the entrepreneurs are individuals with distinctive and specific personality traits. Personality traits have direct impact on many entrepreneurial activities including the intention to launch a new business, success in business, and enhance entrepreneurial set up. Realizing the importance of entrepreneurship for social and economic development of Nigeria, entrepreneurship is a topic requiring a lot of attention from academics and researchers. According to Owoseni (2012) entrepreneurship is the ability to create and build something from practically nothing. It is initiating, doing, achieving and building an enterprise or organization, rather than just watching, analysing or describing one. It is knack for sensing an opportunity where others see chaos, contradiction and confusion. It is the ability to build a “founding team” to complement your own skills and talents. It is willingness to take calculated risk, both personal and financial and then do everything possible to get the odds in your favour. An entrepreneur is one who created and grows a new enterprise and demonstrates characteristics of risk taking and innovation. Individuals who seek entrepreneurial careers are high in achievement motivation, take moderate risks, have more inclination and ability to innovate and have internal (rather than external) locus of control (Owoseni, 2011).

According to Olawoye (2008), small businesses contribute in no small way towards promoting industrial and economic development in any nation given the right environment. Their contributions have been well noticed over the years in the achievement of the following economic development objectives: employment generation; transformation of indigenous technology; utilization of local materials; increase of revenue for government; output expansion and production of intermediate goods.

Photocopy and Video Production Services

Production services means motion picture and video processing, printing, editing, duplicating, animation, graphics, special effects, negative cutting, conversions to other formats or media, stock footage, sound mixing, re-recording sound sweetening, sound looping, sound effects, and automatic dialog replacement. Video production business means a person engaged in the production of motion pictures and videotapes for exhibition, sale, or for broadcast by a person other than the person producing the master copy of a video production. Video production business typically provides a variety of services, such as production services of motion picture or videography (Department of Revenue, 2022).

The Process of Photocopying

Popoola (2013) itemises the process of photocopying as follows:

1. copier's drum is given a positive change;
2. the image from the original copy illuminates the charged drum and a latent image is formed;
3. static electricity attracts toner to the drum surface and visible image is formed;
4. toner on the drum is transferred to paper by positive charging;
5. after the image transfer is completed, the paper is separated from the drum surface;
6. toner on the copy paper is firmly fixed when the paper runs between heat and pressure rollers;
7. a cleaning blade wipes off excess toner;
8. the drum is exposed by a neon lamp to erase the remaining static charge; and finally
9. the paper comes out on the tray.

How to break into the Video Technology Field as a graduate by Alex (2018)

Build skills: It is essential to have a strong foundation in both the theoretical and practical aspect of video editing software, understand the basics of cinematography and get a grasp of post-production techniques, consider online tutorials or community college, courses to bolster your knowledge, practice shooting and editing your own video to apply what you have learned.

Gain Experience: Securing internships or entry-level positions is a crucial step towards entering the video technology industry. These opportunities provide you with real-world experience and a chance to see industry professionals in action. Aim to work on a variety of projects to broaden your skill set and understand different aspects of video production. Even volunteering for small projects or local organizations can be beneficial. Every bit of experience counts and helps build your resume, making you a more attractive candidate to potential employers.

Network Actively: Networking is key in the video technology sector. Start by connecting with alumni from your school who are working in the industry. Attend industry conferences, workshops, and seminars to meet professionals and learn about the latest trends and technologies. Join online forums and social media groups focused on video technology engaging with peers and experts can lead to valuable advice, mentorship opportunities and even job leads. Remember, the relationships you build now can open doors throughout your career.

Creativity, Innovation and Edutechpreneurship

Maa1uhali (2000) in Abiola and Ibitoye (2023) defined creativity as the ability to make or bring into being something, whether a new solution to a problem, a new method or device or a new artistic object form. Wyikoff (2000) in Abiola et al (2023) in his view sees creativity as "new and useful". It is the art of seeing things that everyone around us sees while making connections that no one else had made. Creativity could also be looked at, as moving from known to unknown, having the ability to generate new ideas by combining, changing or reapplying existing ideas. Harris (2000) in Abiola et al (2023) opined that some creative ideas are astonishing and brilliant, while others are first simple, good of practical values that no one seems to have taught of yet. An entrepreneur or enterprise must recognise that modern business operates \n a world galloping with change which creates new problems that would mobilize the entrepreneur's resources so that the changes could make an impact.

Creativity is also known as the act of turning new and imaginative ideas into reality. The report of World Bank (2000) sees creativity as characterized by the ability to perceive the world in new ways, to find hidden patterns, to make connections between seemingly unrelated phenomena, and generate solutions. It is the process of bringing something new to being. It requires passion and commitment, bringing to our awareness what was previously hidden and pointing to new life. Creativity involves two processes: thinking, then acting. For instance, a graduate of vocational and technical education with good ideas must also be able to be creative with the ideas must also be able to be creative with the ideas. So creating is the price of development, innovation pays the bills.

Druker (2007) in Abiola, et al (2023) argued that innovation is a tool of entrepreneurship. He added that both innovation and entrepreneurship demand creativity. Innovation refers to adding something new to an existing product or process. The keywords are "adding" and existing", the process or product has already been created from scratch and has worked reasonably well. When it is changed so that it works better or fulfils different needs, then innovation is carried out on what already exists. Innovation is the successful exploitation of new ideas all innovations begin with creative ideas.

Innovation is based on introducing change into a relatively stable system. The US Department of Labour(2002) described innovation as the implementation of a new or significantly improved product, service or process that creates value for business, government or society. It is concerned with the work required to make a creative idea viable. To be a youth, full of energy and potential is good, but empowering the youth for productive use of their natural strength and endowment is imperative for peace, employment generation and poverty reduction. Edutechpreneurship are three words coined together which are Educational Technology and Entrepreneurship. Educational Technology is an enlarged field of study that comprises two key words which are "education "and "technology". Educational technology as a subject has its sole concern with the task of identifying the most suitable appropriate and developed technology (both hardware and software) for serving the educational needs and purposes of the students and society at a particular time and place. As educational technology serves educational needs, it enhances the acquisition of skills, attitudes, values, culture, ideas, among others in students in turn affects the development of society. Entrepreneurship on the other hand is the process of identifying, creating, and developing a new business venture with the aim of generating profit or value. It involves taking risks, innovating, and organizing resources to bring an idea to life. Essentially, it is about launching and running a business with the goal of making money while also potentially creating positive change. Photocopy and video production in educational technology are skills enhancing that if well mastered by the students stands to form a means of livelihood or makes one an entrepreneur in the workplace and even elsewhere.

Conclusion

Entrepreneurs are keen observers of the market, spotting unmet needs or gaps where they can offer a new product, service, or solution. Entrepreneurship often involves thinking outside the box and developing novel approaches to address problems or meet demands irrespective of the risk involved. Entrepreneurs need to gather the necessary resources, such as capital, personnel, and materials, to get their business off the ground. The ultimate goal of entrepreneurship is to create something of value, whether that is a product, a service, or a positive impact on society. Engaging in an entrepreneurial in a workplace is mainly to secure a key which is no other than profit making. Photocopy and video production, if embark on as business venture is capable sustaining lives and overcoming financial crises.

Recommendations

For future development, this paper is making the following recommendations:

1. The curriculum planners should emphasise the need for continuous existence of entrepreneurship enhancing programmes in the curriculum at all levels of education because of its ability to create employment.
2. Government at all levels should accept and publish entrepreneurship as a hub of innovation that provides new product ventures, market, technology and quality of goods, as well as increase the standard of living of people.
3. The society and community should embrace the developmental impact of entrepreneurship as it assists the organisation towards a more stable and high quality of community life.
4. Individuals and families should tailor their mind towards entrepreneurship because it helps to improve the standard of living of a person by increasing the income.
5. The researchers should equally embrace entrepreneurial enterprise as it gives insights into making enquiries about new products which will promote research, general contribution, and development in the economy.

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COLLEGES OF EDUCATION PRE-SERVICE TEACHERS' SELF-EFFICACY AND ATTITUDE ON THE USE OF MULTI-MEDIA MICRO TEACHING LABORATORY

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Abstract
This study explores the self-efficacy and attitude of pre-service teachers in Colleges of Education regarding the use of the Multimedia Microteaching Laboratory (MML) as an instructional tool. With the increasing integration of technology in teacher education, understanding how future educators perceive and utilize multimedia-supported environments is crucial for effective teacher preparation. The research investigates the level of confidence pre-service teachers exhibit (self-efficacy) and their general disposition (attitude) toward the use of MML in developing teaching skills, including lesson planning, classroom management, and instructional delivery. Findings reveal that positive self-efficacy and favorable attitudes toward multimedia microteaching correlate significantly with improved instructional competence and reflective practice. The study recommends enhanced training and resource allocation to foster a more engaging and innovative microteaching experience.
Keywords words: self-efficacy, attitude, pre-service teachers, Colleges of Education, Multimedia Microteaching Laboratory, teacher preparation, and technology integration

Introduction

Technology enables educators to engage students more effectively, enhance comprehension, and provide a dynamic learning environment. The combination of two or more technological tools during teaching and learning activity is known as multimedia. Multimedia technology encompasses computer-controlled integration of texts, graphics, drawings, still and moving images (video), animation, music, and any other media where any sort of information may also be expressed, saved, transferred, and processed digitally (Otsupius 2014, Hwang, Lai, & Wang, 2017). Multimedia technology comprises a range of digital tools, including audio, video, graphics, animations, and interactive software.

Multimedia technology has the potential to enhance engagement and motivation, multimedia elements can captivate learners' attention and make learning more enjoyable, leading to increased interest in subject matter and improve comprehension. Visual and auditory aids can help clarify complex concepts and facilitate better understanding, foster interactive learning. Multimedia technology can provide opportunities for active participation and firsthand experiences, which are crucial for effective learning and facilitate self-paced learning (Hwang, et. al. 2017).

Pre-service teachers are individuals who are under training for their teacher education programme and preparing for careers in education. They are tasked with acquiring the necessary skills, knowledge, and attitudes to become effective facilitators who can facilitate meaningful learning experiences for their future learners. Given the evolving landscape of education, it is imperative that pre-service teachers while undergoing training are equipped with the latest tools and techniques particularly in the context of micro-teaching as it allows translating theory into practice to meet the demands of 21st-century learners (Hwang et al., 2017). Pre-service teachers can revisit multimedia resources at their own pace, allowing for personalized learning experiences in their respective institutions of higher learning such as Colleges of Education (Otsupius, 2014 & Hwang et al., 2017).

Multimedia micro-teaching laboratories have emerged as a powerful tool for enhancing teacher education programmes in Colleges of Education in Nigeria. These laboratories offer pre-service teachers a dynamic platform to practise teaching skills in a controlled and immersive environment. However, the acceptance and utilisation of multimedia micro-teaching laboratories by pre-service teachers in Colleges of Education remains a critical issue. Understanding the factors that influence their acceptance is vital for optimising teacher training and improving the quality of education. Despite the potential benefits of multimedia micro-teaching laboratories, there is a noticeable gap in literature that shows how pre-service teachers accept teaching tools.

Research Questions

1. What is the level of self-efficacy of Colleges of Education pre-service teachers regarding the use of the multimedia micro-teaching laboratory?
2. What are the attitudes of College of Education pre-service teachers towards the multimedia micro-teaching laboratory?

Research Hypothesis

1. There will be no significant effect on the level of self-efficacy of colleges of Education pre-service teachers regarding the use of the multimedia micro-teaching laboratory
2. There will be no significant effect on the attitudes of colleges of Education pre-service teachers regarding the use of the multimedia micro-teaching laboratory

Methodology

The study adopted the descriptive survey research design of the cross-sectional type,

Purposive sampling technique was used to select eleven Colleges of Education (4 Federal and 7 State Colleges of Education) because they all have multimedia micro-teaching laboratories. Thereafter, stratification was used to select students from Colleges of Education, three thousand and eight is the total sample size. A self-developed instrument was used to obtain relevant data for the study is a researcher designed questionnaire titled Pre-service Teachers' Multimedia Micro -Teaching Laboratory Questionnaire (PTMMTLQ). The data analysis for this study incorporated both descriptive and inferential statistical methods. Descriptive statistics of means and standard deviations were employed to provide an overview of the data and specifically address the research questions 1-8 using a benchmark of 2.5. For the inferential component, multiple regression analysis was utilized to test the study's hypotheses, with a significance level set at 0.05.

Result

Research Question 1: What is the level of self-efficacy of Colleges of Education pre-service teachers regarding the use of the multimedia micro-teaching laboratory**?**

Table 1: Pre-service teachers perceived self-efficacy of multimedia micro-teaching laboratory

S/N	**Perceived Self-Efficacy**	Mean	SD
1	I can use MMTL to generate effective meaning by sending and receiving signs and symbols in microteaching.	3.23	0.73
2	I can use MMTL to communicate with lecturers and others in the group in microteaching.	3.32	0.80
3	I can use MMTL to interpret information received from others in microteaching.	3.03	0.90
4	I can use MMTL to aid reinforcement in microteaching.	3.29	0.83
5	I can use MMTL for instructional closure when the lesson is completed, and the teacher shows the link between past knowledge and new knowledge in microteaching.	3.07	0.84
6	I can use MMTL for cognitive closure when the students have reached closure and have made the link between old and new knowledge in microteaching.	3.24	0.86
7	I can use MMTL for social closure by easily giving a feeling of achievement after a lesson and encouraging them to continue to strive and make improvements in microteaching.	3.22	0.91
8	I can use MMTL in establishing a link between what students had known before and what is introduced, moving from old to new materials and linking the two in microteaching.	3.39	0.59
9	I can use MMTL in establishing a framework to assess the impact and effectiveness of lessons in microteaching.	3.22	0.80
10	I can use MMTL in giving meaning to a new concept or principle, such as giving examples in microteaching.	3.41	0.72
11	I can use MMTL in creating stimulus in class and varying it in microteaching.	3.52	0.60
12	I can use MMTL in structuring the use of the board during microteaching.	3.10	0.92
	Average Mean	3.25	

Table 9 reveals how pre-service teachers evaluated their self-efficacy in using multimedia micro-teaching laboratory (MMTL). Pre-service teachers reported using MMTL for various purposes in micro-teaching. They use MMTL to generate effective meaning through signs and symbols (3.23), communicate with lecturers and group members (3.32), and interpret information from others (3.03). MMTL is also used to aid reinforcement (3.29) and for different types of lesson closures: instructional (3.07), cognitive (3.24), and social (3.22).

Furthermore, pre-service teachers utilize MMTL in establishing links between students' prior knowledge and new material (3.39), assessing lesson impact and effectiveness (3.22), and giving meaning to new concepts or principles through examples (3.41). They also use MMTL to create and vary classroom stimuli (3.52) and structure the use of the board during micro-teaching (3.10). Overall, with an average mean of 3.25 (81.3%), the results suggest that pre-service teachers found the multimedia micro-teaching laboratory efficient in enhancing their teaching practices across various aspects of micro-teaching.

Research Question 2: What are the attitudes of Colleges of Education pre-service teachers towards the multimedia micro-teaching laboratory**.**

Table 2: Colleges of Education pre-service teachers' attitude towards multimedia micro-teaching laboratory.

S/N	Attitude	Mean	SD
1	I like being assessed for microteaching using multimedia.	3.05	0.89
2	I like to be involved in microteaching using multimedia.	3.02	0.85
3	I attend microteaching class using the multimedia laboratory.	3.07	0.87
4	The multimedia microteaching laboratory does not scare me at all.	3.08	0.76
5	Using the multimedia microteaching laboratory would make me very nervous.	3.12	0.77
6	I do not feel threatened when others talk about the multimedia microteaching laboratory for microteaching.	2.99	0.86
7	I would feel at ease in a multimedia microteaching laboratory for microteaching.	2.94	0.85
8	I get a sinking feeling when I think of trying to use the multimedia microteaching laboratory.	3.02	0.98
9	I would feel comfortable working with the multimedia microteaching laboratory.	3.06	0.92
10	The multimedia microteaching laboratory makes me feel uneasy and confused in microteaching.	3.06	0.92
	Average Mean	3.04	

Table 10 reveals the attitudes of Colleges of Education pre-service teachers towards multimedia micro-teaching laboratory (MMTL). The results indicate generally positive attitudes across various aspects of MMTL use: Pre-service teachers expressed a liking for being assessed (3.05) and involved (3.02) in microteaching using multimedia. They reported attending microteaching classes using multimedia laboratory (3.07). The data suggests that MMTL does not significantly intimidate students, with responses indicating that it doesn't scare them (3.08) and that they don't feel threatened when others discuss MMTL for microteaching (2.99). While there's a slight indication of nervousness about using MMTL (3.12), students generally reported feeling at ease in a multimedia microteaching laboratory (2.94) and comfortable working with it (3.06). The "sinking feeling" when thinking about using MMTL was moderate (3.02), and feelings of unease and confusion were similarly middling (3.06). Overall, with an average mean of 3.04 (76%), the results reveal that Institutes of Education pre-service teachers maintained a positive attitude towards multimedia micro-teaching laboratory. This suggests that while there may be some apprehension, the overall sentiment towards MMTL is favorable, indicating its potential for effective integration into teacher training programs.

Conclusion

This study is on multimedia micro-teaching laboratory: acceptance and usage among pre-service teachers in Colleges of Education, South-western Nigeria and leads to findings which indicated that multimedia micro-teaching laboratories have a positive impact on pre-service teachers' self-efficacy, attitude toward teaching, and actual usage of these facilities. These outcomes are significant as they contribute to the overall preparation and effectiveness of future educators.

Recommendations

1. Continuous monitoring and evaluation is also required to track changes in acceptance and usage over time, ensuring that the laboratory remains a valuable resource for pre-service teachers.
2. Colleges of Education should provide tailored support and training programme that address the specific needs and preferences of pre-service teachers. This approach includes organising workshops on multimedia integration and providing one-on-one assistance.

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COMMERCIALISATION STRATEGIES FOR BALANCING PROFITABILITY AND EDUCATIONAL IMPACT IN SCALABLE EDTECH TOOLS IN TERTIARY INSTITUTIONS IN LAGOS STATE

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Abstract

This systematic review meticulously examines commercialization strategies that effectively balance profitability with profound educational impact in scalable Education Technology (EdTech) tools specifically within tertiary institutions in Lagos State, Nigeria. It delves into the intricate dynamics of how EdTech solutions can achieve financial viability while simultaneously fostering significant pedagogical advancements. The review synthesizes an extensive body of current literature, encompassing diverse perspectives on EdTech business models, established commercialization frameworks, and their practical application within the unique socio-economic and educational landscape of Nigerian higher education. A particular emphasis is placed on exploring the critical considerations of scalability, ensuring that successful strategies can be replicated and expanded to reach a wider student population, and sustainability, guaranteeing the long-term viability and positive influence of these EdTech initiatives.

Keywords: Scalable, EdTech Tools, Commercialization, Profit

Introduction

The education technology (EdTech) sector is currently undergoing an unprecedented period of global expansion, characterized by rapid innovation and substantial investment. Projections indicate a monumental growth trajectory, with the market anticipated to surge from an estimated $215.14 billion in 2024 to an impressive $773.06 billion by 2033. This exponential growth underscores a worldwide recognition of EdTech's transformative potential in reshaping educational paradigms and enhancing learning outcomes across various levels of education. Within this dynamic global context, Nigeria, as a prominent African nation with a burgeoning youth population and increasing digital penetration, presents a compelling and unique landscape for EdTech development and implementation. Specifically, within its tertiary institutions, there exists a pressing and multifaceted need for scalable and sustainable educational solutions that can effectively address the challenges of access, quality, and relevance, all while navigating the imperative of commercial viability. This intersection of educational necessity and market opportunity forms the core focus of this systematic review, aiming to unravel the complexities of balancing financial success with genuine educational impact in the Nigerian higher education sector.

Objectives

To comprehensively address the study, a systematic review is guided by the following specific objectives:

1. Identify key commercialization strategies employed by successful EdTech companies globally and, where applicable, within the Nigerian context thorough examination of various business models and revenue generation approaches that have proven effective in the EdTech sector.
2. Analyze the intricate balance between profitability and educational impact in existing EdTech commercialization models by seeking to understand how financial goals are aligned with, or potentially diverge from, the core mission of enhancing education.
3. Examine the specific scalability challenges inherent to tertiary institutions in Lagos State, Nigeria by an investigation into infrastructural limitations, digital literacy disparities, and other contextual factors that may impede the widespread adoption and effective utilization of EdTech tools.
4. Propose robust and adaptable frameworks for sustainable EdTech commercialization specifically tailored to the Nigerian context with an actionable insights and recommendations for EdTech companies and policymakers seeking to foster long-term success and positive societal impact.

Research Question

The following research questions will be answered in the study

1. What are key commercialization strategies employed by successful EdTech companies globally and, where applicable, within the Nigerian context thorough examination of various business models and revenue generation approaches that have proven effective in the EdTech sector?
2. What are the intricate balance between profitability and educational impact in existing EdTech commercialization models by seeking to understand how financial goals are aligned with, or potentially diverge from, the core mission of enhancing education?
3. What are the specific scalability challenges inherent to tertiary institutions in Lagos State, Nigeria by an investigation into infrastructural limitations, digital literacy disparities, and other contextual factors that may impede the widespread adoption and effective utilization of EdTech tools?
4. What frameworks is sustainable for EdTech commercialization specifically tailored to the Nigerian context with an actionable insights and recommendations for EdTech companies and policymakers seeking to foster long-term success and positive societal impact?

Methodology

This review adheres to rigorous methodological standards to ensure comprehensive and unbiased collection, analysis, and synthesis of relevant literature. The methodology is designed to provide a robust foundation for addressing the research question and achieving the stated objectives. A comprehensive and systematic literature search was meticulously conducted across a diverse range of academic databases and other pertinent sources to capture a broad spectrum of relevant publications. The search strategy was designed to maximize coverage and minimize bias, utilizing a combination of keywords related to EdTech, commercialization, profitability, educational impact, scalability, tertiary education, and Nigeria. Different databases and sources were primarily utilized. Academic databases such as PubMed, IEEE Xplore, and Education Database were selected for their extensive coverage of scientific, engineering, and educational research, respectively. These databases provided access to peer-reviewed articles, conference papers, and scholarly publications. To gain insights into practical applications and market trends, relevant reports and white papers from reputable EdTech industry associations, market research firms, and technology consultants were included. These documents often provide valuable data and case studies not typically found in academic literature. Official publications from Nigerian government bodies, ministries of education, and regulatory agencies were reviewed to understand the policy landscape, national initiatives, and regulatory frameworks influencing the EdTech sector in Lagos State and Nigeria as a whole. To ensure the timeliness and relevance of the review, a specific focus was placed on incorporating the most recent market research reports, providing up-to-date data on market size, growth projections, emerging trends, and investment patterns within the global and Nigerian EdTech markets.

Inclusion Criteria

To ensure relevance and focus, studies and documents were included if they met all of the following criteria:

Publication Date: Studies published between 2020 and 2025 were prioritized to capture the most current trends and developments in the rapidly evolving EdTech landscape.

Thematic Focus: The primary focus of the study or document had to be on EdTech commercialization strategies, encompassing various business models, revenue generation mechanisms, and market entry approaches.

Educational Level: The content needed to be directly relevant to tertiary education or higher education institutions, including universities, polytechnics, and colleges of education.

Geographical Relevance: Studies that considered emerging markets or developing economies, particularly those in Africa, were included to provide contextual insights relevant to Nigeria.

Scalability Analysis: The study or document had to include an analysis of scalable business models or strategies, addressing how EdTech solutions can expand their reach and impact.

Exclusion Criteria

Conversely, studies and documents were excluded if they met any of the following criteria:

Educational Level: Studies focused solely on K-12 (primary and secondary) education were excluded, as the review's scope is specifically tertiary institutions.

Nature of Content: Theoretical papers without practical application or empirical evidence were excluded to ensure the review's focus on actionable strategies.

Publication Date: Studies older than 5 years (pre-2020) were generally excluded, unless they were identified as seminal works that laid foundational concepts still highly relevant to the current EdTech landscape.

Language: Non-English publications were excluded unless readily available and accurate translations were provided, to ensure the feasibility of comprehensive review.

Literature Review

This section presents a comprehensive review of the existing literature, synthesizing key findings related to the current EdTech market landscape, various commercialization strategies, and the critical balance between profitability and educational impact. The insights gleaned from this review form the empirical basis for the subsequent analysis and recommendations.

Current EdTech Market Landscape

The global EdTech market is not merely growing; it is undergoing a profound transformation, driven by technological advancements, evolving pedagogical approaches, and an increasing demand for flexible and accessible learning opportunities. The robust growth trajectories observed across various segments of the EdTech industry underscore its significant economic footprint, with education collectively representing over 6% of the global Gross Domestic Product (GDP). This substantial contribution highlights the sector's integral role in national and international economies. Furthermore, investor confidence in the EdTech sector remains exceptionally high, as evidenced by the impressive average revenue multiple for EdTech startups, which stood at 14.4x in 2024. This figure significantly surpasses the average for the broader Software as a Service (SaaS) industry, which typically hovers around 8.1x. This disparity in valuation multiples signals a strong market belief in EdTech's inherent potential for scalable, profitable business models that can deliver both financial returns and substantial societal value. The market's confidence is rooted in the understanding that effective EdTech solutions can address critical educational gaps, improve learning efficiencies, and democratize access to quality education on an unprecedented scale.

Commercialization Strategies in EdTech

EdTech companies employ a diverse array of commercialization strategies to generate revenue and sustain their operations. These strategies are often adapted to specific market conditions, target audiences, and the nature of the EdTech tool itself. The following subsections detail some of the most prevalent and effective models identified in the literature:

Subscription-Based Models (SaaS)

Subscription-based models, often implemented as Software as a Service (SaaS), represent a cornerstone of commercialization in the EdTech sector. This model provides a predictable and recurring revenue stream, which is crucial for the long-term financial health and continuous product development of EdTech companies. For scalable EdTech tools, the subscription model offers several distinct advantages:

Ensures Recurring Revenue for Sustained Operations: By charging a regular fee (monthly, quarterly, or annually), EdTech providers can forecast their income more accurately, enabling stable operations and strategic planning. This predictability is vital for investing in research and development, customer support, and infrastructure.

Allows for Iterative Product Improvements: The continuous revenue flow supports ongoing product development cycles. This means companies can regularly release updates, new features, and bug fixes, ensuring their platforms remain competitive and responsive to user needs and technological advancements. This iterative approach fosters a dynamic and evolving learning environment.

Provides Predictable Cash Flow for Expansion: A stable and predictable cash flow facilitates strategic expansion into new markets, development of new products, or acquisition of complementary technologies. This financial stability is particularly important for EdTech companies aiming for widespread adoption and significant educational impact.

Enables Tiered Pricing for Different Institutional Needs: Subscription models can be highly flexible, allowing for tiered pricing structures. This means institutions can choose from various packages based on their size, specific requirements, number of users, or desired features. This flexibility makes EdTech solutions accessible to a broader range of tertiary institutions, from small colleges to large universities, and allows for customization based on budget and pedagogical goals.

Freemium Models

Freemium models involve offering a basic version of an EdTech tool for free, while charging for premium features, advanced functionalities, or enhanced support. This strategy is particularly effective in markets characterized by price sensitivity, such as Nigeria, where budget constraints within tertiary institutions are a significant consideration. The advantages of a freemium model include:

Lower Barrier to Entry: Institutions and individual users can experience the core value of the EdTech tool without an upfront financial commitment, reducing perceived risk and encouraging adoption.

Wider User Acquisition: The free tier acts as a powerful marketing tool, attracting a large user base and fostering organic growth through word-of-mouth and positive user experiences.

Demonstration of Value: Users can thoroughly test the basic functionality and understand the benefits of the tool before deciding to upgrade to a paid version. This hands-on experience builds trust and demonstrates the tangible value proposition.

Targeted Conversion: By analyzing user engagement with the free tier, EdTech companies can identify power users or institutions that would benefit most from premium features, allowing for targeted marketing and sales efforts.

Marketplace Models

Marketplace models in EdTech create platform-based ecosystems that connect various stakeholders, including educators, students, content creators, and sometimes even employers. These platforms facilitate the exchange of educational resources, courses, and services, generating

revenue through commissions, transaction fees, or premium listings. This model offers significant potential for scalable business opportunities with relatively low overhead costs, while simultaneously maintaining a strong focus on educational value:
Scalability through Network Effects: As more users (educators, students, content creators) join the platform, its value increases exponentially, attracting even more participants. This inherent network effect drives rapid scalability.
Diverse Revenue Streams: Revenue can be generated through various mechanisms, such as a percentage of course sales, subscription fees for premium content, advertising, or lead generation for educational programs.
Low Content Creation Overhead: Unlike traditional EdTech companies that develop all their content in-house, marketplace models leverage user-generated content, significantly reducing content creation costs and allowing for a wider variety of offerings.
Enhanced Educational Value: By bringing together a diverse range of educators and content, marketplace models can offer a rich and varied learning experience, catering to diverse learning styles and subject matter interests.

Enterprise Licensing

Enterprise licensing involves selling a license for an EdTech solution directly to an entire institution (e.g., a university, a department, or a faculty) rather than to individual users. This commercialization strategy provides substantial revenue opportunities for EdTech companies while simultaneously ensuring widespread educational impact through institutional adoption. Key aspects of enterprise licensing include:
Large-Scale Adoption: A single licensing agreement can provide access to thousands of students and faculty members, leading to significant and immediate educational reach.
Predictable and Substantial Revenue: Enterprise licenses typically involve larger contracts and longer terms, providing a stable and substantial revenue stream for the EdTech provider.

Integration with Institutional Systems: Enterprise solutions are often integrated directly into the institution's existing Learning Management Systems (LMS) or other IT infrastructure, ensuring seamless access and utilization for all users.
Enhanced Support and Training: Enterprise agreements often include dedicated support, training programs for faculty and administrators, and customized implementation plans, ensuring effective adoption and utilization of the EdTech tool within the institutional context.

Balancing Profitability and Educational Impact: The most successful EdTech companies recognize that long-term profitability is inextricably linked to demonstrable educational impact. Achieving this delicate balance requires innovative approaches that align commercial interests with the core mission of enhancing learning. Several strategies have emerged to foster this synergy:

Impact Investing Trends

Recent trends in the investment landscape indicate a growing emphasis on impact investing in EdTech. This approach signifies a paradigm shift where financial returns are not the sole metric of success; instead, they are meticulously balanced with measurable educational outcomes. Impact investors actively seek ventures that generate positive social or environmental impact alongside financial gains. In the EdTech sector, this translates to investments in tools and platforms that demonstrably improve learning outcomes, enhance access to education, or address critical educational disparities. This alignment of commercial interests with an overarching educational mission fosters a more sustainable and ethically driven business model. Companies that can clearly articulate and measure their educational impact are increasingly attractive to this growing segment of investors, leading to a virtuous cycle where financial success is directly tied to positive societal contributions.

Outcome-Based Pricing

Outcome-based pricing models represent a significant innovation in EdTech commercialization, directly linking the cost of a service or product to the achievement of specific, predefined educational outcomes. This approach shifts the risk from the educational institution to the EdTech provider, as payment is contingent upon the successful delivery of measurable results. For instance, an EdTech company might be compensated based on improvements in student test scores, increased graduation rates, or enhanced student engagement metrics. This model inherently aligns the financial incentives of the EdTech provider with the educational goals of the institution, ensuring that profitability correlates directly with actual educational impact. It encourages EdTech companies to develop highly effective and evidence-based solutions, as their revenue is directly tied to the value they create for learners and institutions. This model also promotes transparency and accountability, as both parties must agree on clear, measurable outcomes and the methods for assessing them.

Partnership Models

Collaborative partnership models are increasingly vital for EdTech companies seeking to achieve both financial sustainability and broad educational access, particularly in complex and resource-constrained environments. These partnerships can take various forms, involving educational institutions, government agencies, non-governmental organizations (NGOs), and even local communities. By forging strategic alliances, EdTech companies can leverage complementary strengths, share resources, and mitigate risks. For example, partnerships with government agencies can provide access to large-scale funding, policy support, and distribution channels, facilitating widespread adoption. Collaborations with educational institutions ensure that EdTech solutions are tailored to specific pedagogical needs and integrated effectively into existing curricula. NGOs can provide invaluable insights into local contexts and help reach underserved populations. These partnerships often lead to more sustainable funding mechanisms, such as grants, public-private partnerships, or shared revenue models, while simultaneously ensuring that EdTech solutions are accessible to a wider audience and genuinely address pressing educational challenges.

Nigerian EdTech Context

Nigeria, with its vast population and rapidly developing digital infrastructure, presents a unique and dynamic landscape for the EdTech sector. Understanding the specific opportunities and challenges within this context is crucial for developing effective commercialization strategies.

Market Opportunities

The Nigerian EdTech sector is poised for significant growth, driven by several compelling factors:

Large Student Population in Tertiary Institutions: Nigeria boasts one of the largest youth populations globally, with a substantial and ever-growing number of students seeking higher education. This demographic dividend creates an immense demand for scalable and accessible educational resources, which EdTech tools are uniquely positioned to address.

Increasing Internet Penetration: While challenges remain, internet penetration in Nigeria has been steadily increasing, particularly with the proliferation of affordable smartphones and expanding mobile network coverage. This growing connectivity provides a foundational infrastructure for the widespread adoption and utilization of online learning platforms and digital educational tools.

Government Initiatives Supporting Digital Education: The Nigerian government, recognizing the transformative potential of technology in education, has initiated various policies and programs aimed at promoting digital literacy, integrating ICT into curricula, and supporting EdTech innovation. These initiatives create a more conducive regulatory and supportive environment for EdTech companies.

Growing Demand for Flexible Learning Solutions: Traditional educational models often struggle to accommodate the diverse needs of a large and varied student population. There is a strong and increasing demand for flexible learning solutions, including online courses, blended learning approaches, and self-paced modules, which EdTech platforms can effectively deliver.

Challenges Specific to Lagos State

Despite the promising opportunities, the implementation and scaling of EdTech tools in Lagos State tertiary institutions face several specific challenges that must be carefully navigated:

Infrastructure Limitations Affecting Scalability: While internet penetration is growing, reliable and high-speed internet access remains a significant challenge in many areas, particularly outside major urban centers. Furthermore, consistent electricity supply is often an issue, impacting the ability of students and institutions to consistently access and utilize digital learning resources. These infrastructural limitations can hinder the seamless scalability of online platforms.

Varying Levels of Digital Literacy Among Users: There is a considerable disparity in digital literacy levels among students and faculty members in Nigerian tertiary institutions. While many are tech-savvy, a significant portion may lack the necessary skills to effectively utilize advanced EdTech tools, requiring substantial investment in training and support.

Budget Constraints in Public Institutions: Public tertiary institutions in Lagos State often operate under severe budget constraints, limiting their ability to invest in expensive EdTech solutions or robust digital infrastructure. This necessitates the development of cost-effective and flexible pricing models by EdTech providers.

Competition from International EdTech Platforms: The Nigerian EdTech market is not insular; it faces significant competition from well-established international EdTech platforms that often have greater financial resources, advanced technologies, and extensive content libraries. Local EdTech companies must differentiate themselves through localized content, culturally relevant pedagogical approaches, and superior customer support.

Scalability Considerations

For EdTech tools to achieve widespread impact and financial viability in Lagos State, scalability is paramount. This involves both technical and business model considerations.

Technical Scalability

Successful EdTech tools must be designed to handle increasing user loads while maintaining optimal performance and user experience. Key technical considerations for scalability in the Nigerian market include:

Cloud-Based Architectures: Leveraging cloud computing platforms (e.g., AWS, Azure, Google Cloud) is crucial for ensuring technical scalability. Cloud infrastructure provides the flexibility to rapidly scale resources up or down based on demand, ensuring that the platform can accommodate a growing number of users without compromising performance. This also reduces the need for significant upfront capital expenditure on physical servers.

Mobile-First Designs: Given the high penetration of mobile devices and often limited access to desktop computers, designing EdTech tools with a mobile-first approach is essential. This ensures that platforms are optimized for smaller screens, touch interfaces, and varying network conditions, making them accessible to a wider student population. Responsive design and lightweight applications are key.

Business Model Scalability

Beyond technical considerations, the business model itself must be inherently scalable to thrive in the Nigerian context. This requires adaptability and a deep understanding of the local market dynamics:

Flexible Pricing Structures Accommodating Different Institution Types: As highlighted earlier, budget constraints vary significantly across public and private institutions. Scalable business models must offer flexible pricing tiers, payment plans, and potentially even outcome-based pricing to cater to the diverse financial capacities of tertiary institutions in Lagos State.

Local Partnership Networks for Distribution and Support: Building strong local partnership networks is critical for effective distribution, marketing, and customer support. Collaborating with local educational consultants, community leaders, and technology providers can facilitate market penetration and ensure that users receive timely and culturally appropriate assistance.

Cultural and Linguistic Adaptations: EdTech content and interfaces must be culturally relevant and, where appropriate, linguistically adapted to resonate with Nigerian learners. This goes beyond mere translation and involves incorporating local examples, case studies, and pedagogical approaches that align with the Nigerian educational system and cultural norms.

Offline Functionality for Areas with Limited Connectivity: To address the challenges of inconsistent internet access, incorporating offline functionality into EdTech tools is a significant advantage. This allows users to download content, complete assignments, and access learning materials even when they are not connected to the internet, synchronizing data once connectivity is restored.

Framework for Lagos State Implementation

To guide the successful commercialization and scaling of EdTech tools in Lagos State tertiary institutions, a phased implementation framework is proposed:

Phase 1: Market Entry

This initial phase focuses on establishing a strong foothold and validating the EdTech solution within the Lagos State context:

Partner with 2-3 Flagship Institutions for Pilot Programs: Initiating pilot programs with a select number of reputable and forward-thinking tertiary institutions allows for real-world testing, gathering valuable feedback, and demonstrating the efficacy of the EdTech tool in a controlled environment. These flagship partnerships can serve as powerful case studies for future expansion.

Develop Localized Content and Language Support: Content must be adapted to the Nigerian curriculum and context, incorporating local examples, case studies, and cultural nuances. While English is widely spoken, providing support for local languages where feasible can enhance user engagement and comprehension.

Establish Relationships with Regulatory Bodies: Proactively engaging with relevant government agencies, educational ministries, and regulatory bodies is crucial for understanding and navigating the regulatory landscape, ensuring compliance, and potentially securing government support or endorsements.

Phase 2: Scaling

Once the initial market entry is successful, this phase focuses on expanding the reach and adoption of the EdTech solution:

Implement Referral Programs Among Institutions: Encouraging existing partner institutions to refer the EdTech solution to other tertiary institutions can be a highly effective and cost-efficient scaling strategy. Positive word-of-mouth and demonstrated success within the local context are powerful drivers of adoption.

Develop Training Programs for Faculty and Administrators: To ensure effective utilization and integration of the EdTech tool, comprehensive training programs must be developed and delivered

for both faculty members and administrative staff. This empowers educators to leverage the technology effectively in their teaching and helps administrators manage the platform efficiently.
Create Sustainable Pricing Models Based on Institutional Capacity: Building upon the flexible pricing structures, this phase involves refining pricing models based on the specific financial capacities and needs of different types of institutions (e.g., public vs. private, large vs. small). This ensures affordability and broad accessibility.

Phase 3: Sustainability

The final phase focuses on ensuring the long-term viability and continued positive impact of the EdTech solution:
Diversify Revenue Streams Through Multiple Service Offerings: Relying on a single revenue stream can be risky. To ensure long-term sustainability, EdTech companies should explore diversifying their offerings, such as providing premium content, professional development courses for educators, data analytics services, or consulting.
Establish Long-Term Contracts with Proven ROI Demonstration: Securing long-term contracts with institutions is crucial for predictable revenue and sustained operations. This requires clearly demonstrating the return on investment (ROI) of the EdTech solution, both in terms of financial benefits (e.g., efficiency gains) and educational outcomes.
Expand to Other Nigerian States Using Lagos as a Model: Once successful in Lagos State, the framework and lessons learned can be leveraged to expand into other Nigerian states, adapting the strategies to suit regional nuances while maintaining the core principles of balancing profitabilit y and educational impact.

Metrics for Success

To effectively assess the success of EdTech commercialization strategies, a comprehensive set of metrics is required, encompassing both financial performance and educational impact:
Student Engagement and Learning Outcomes: This includes metrics such as active user rates, time spent on platform, completion rates of courses or modules, and, most importantly, measurable improvements in student academic performance and skill acquisition.
Institution Adoption Rates and Retention: Tracking the number of institutions adopting the EdTech solution and their retention rates over time provides insights into market penetration and customer satisfaction.
Revenue per User and Customer Lifetime Value: These financial metrics assess the profitability and long-term value generated from each user or institutional client.
Market Penetration in Tertiary Institutions: This metric measures the percentage of eligible tertiary institutions in Lagos State (and eventually other regions) that have adopted the EdTech solution, indicating the reach and scale of the commercialization efforts.
Social Impact Measurements: Beyond traditional educational outcomes, it is important to measure broader social impacts, such as increased access to education for underserved populations, enhanced digital literacy across the student body, and contributions to national development goals.

Conclusion

In conclusion, the successful commercialization of scalable EdTech tools within tertiary institutions in Lagos State, Nigeria, necessitates a meticulously balanced approach that unequivocally prioritizes both financial sustainability and profound educational impact. The insights gleaned from this systematic review underscore that the most promising strategies are those that seamlessly integrate flexible business models, cultivate robust local partnerships, and are driven by outcome-focused metrics. It is imperative for EdTech companies operating in this dynamic environment to adeptly adapt global best practices to the unique intricacies of the local Nigerian context, all while steadfastly maintaining a clear focus on scalability for achieving enduring success and widespread positive influence.

The Nigerian EdTech market, while replete with significant opportunities, also presents a complex array of challenges, including infrastructural limitations, diverse cultural considerations, and varying institutional capacities. Navigating this intricate landscape successfully hinges upon the development of truly sustainable business models. These models must serve the dual, interconnected purpose of not only generating requisite profits to ensure operational longevity but also, and equally importantly, genuinely improving educational outcomes within tertiary institutions. Ultimately, the long-term success and transformative potential of EdTech in Lagos State, and indeed across Nigeria, will be determined by the capacity of these solutions to deliver tangible, measurable educational value while simultaneously fostering economic viability.

Recommendations

Based on the comprehensive analysis presented in this systematic review, the following key recommendations are put forth to guide EdTech companies, policymakers, and educational institutions in fostering successful and impactful commercialization strategies within Lagos State tertiary institutions:

1. EdTech companies should strategically combine various revenue generation approaches, such as subscription-based models, marketplace functionalities, and enterprise licensing.
2. Implementing flexible and tiered pricing structures is crucial to accommodate the diverse budgetary capacities of different tertiary institutions in Lagos State.
3. Cultivating strong and strategic partnerships with Nigerian educational institutions, government agencies, local technology providers, and community organizations is paramount.
4. Prioritizing mobile accessibility in the design and development of EdTech tools is essential, given the high penetration of mobile devices in Nigeria.

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PERSONALISED LEARNING AND AI TO ENHANCE ACCESS AND EQUITY EDUCATION

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Abstract

In recent years, the integration of personalized learning approaches alongside artificial intelligence (AI) has emerged as a pivotal strategy to enhance access and equity in education. This paper explores the potential of AI-driven personalized learning systems to address diverse learner needs, thereby promoting inclusive educational environments. By leveraging data analytics, machine learning algorithms, and adaptive learning technologies, educators can tailor instructional materials and pedagogical strategies to accommodate individual student preferences, abilities, and learning styles. The paper evaluates the impact of these technologies on reducing educational disparities, particularly for historically marginalized groups, and considers the ethical implications surrounding data use and algorithmic bias. Furthermore, it highlights successful case studies where personalized learning frameworks, powered by AI, have facilitated improved engagement and academic outcomes. Ultimately, this research underscores the necessity for educators, policymakers, and technologists to collaboratively navigate the complexities of AI implementation in educational settings, ensuring that the benefits of personalized learning are accessible to all students, thereby fostering a more equitable educational landscape.

Keywords: Personalised, Equity, Adaptive, Technologies, Disparities.

Introduction

Ensuring equitable access to quality education remains a persistent global concern, especially in developing regions like Nigeria. Advances in Artificial Intelligence (AI) are revolutionizing various sectors, and education must be at the forefront. Accessible education, whether virtually or physically, is a precondition of equity and access to social opportunities, as it remains a fact that people's quality of life is directly linked to their level of education. Education establishes the necessary skills and values for nation-building and socioeconomic development (Aliabadi et al., 2023). Over time, it has become the primary means by which social systems promote equity. Today, education is a universal right. Physical and virtual access to education, whether formal or informal, irrespective of gender, ethnicity, geographic location, age, or ability, is a fundamental human right of existence. Education is an agent of social change. By sharpening knowledge and skills, solving day-to-day problems, and acquiring awareness, education informs the behaviour, attitude, and understanding of an individual and strengthens future relationships with the environment. Education is widely regarded as a fundamental human right and a critical factor in national development. However, inequities in access and quality continue to marginalize millions of learners across the globe. In countries like Nigeria, factors such as poverty, infrastructural deficits, teacher shortages, and socio-cultural barriers intensify these inequalities (Okoye & Adigwe, 2022). The emergence of Artificial Intelligence (AI) expands the possibilities of transforming enormous amounts of information into usable knowledge, thereby enhancing equity and accessibility to education. It offers new avenues for transforming the delivery of education through personalized learning.

Personalized learning refers to instructional methods tailored to the unique needs, interests, and abilities of each student (Pane et al., 2017). When powered by AI, this educational approach can dynamically adapt content, pace, and feedback, thereby fostering engagement, improving outcomes, and democratizing access to education. This paper posits that AI-enabled personalized learning systems can address entrenched disparities and create inclusive education ecosystems.

Conceptual Framework and Understanding Personalised Learning

Personalized learning can be defined as individualising instruction to students' specific needs. This commonly takes the form of adaptive instruction, in which a standard 'learning path' is designed based on a student's ability level, and a computer-based tool monitors the student's progression along that path, adjusting it as necessary. Another form is one-on-one tutoring, in which instruction is presented in a manner and at a pace tailored to a particular student. The theoretical foundation of personalized learning is grounded in Constructivist Learning Theory, which asserts that learners actively construct knowledge based on prior experiences and cognitive development (Vygotsky, 1978). Complementing this is the Universal Design for Learning (UDL) framework, which advocates for multiple means of representation, engagement, and expression to accommodate learner diversity (CAST, 2018).

The idea of personalized learning is based on the belief that students learn best when instruction is adapted to their specific needs. Personalized learning does not only refer to adaptive practice in which hints or prompts are adapted to students' responses or in which learning opportunities are changed based on learning progress. It is more encompassing and entails the personalization of students' learning experience. More specifically, personalized learning is the tailoring of pedagogy, curriculum, instruction, and assessment to the interests, abilities, and needs of each individual student. Ideally, personalized learning should lead to learning gains for all students, which in turn provides a better starting position for each individual student to reach his or her full potential (Dumont & D. Ready, 2023). Hence, personalized learning can serve the interests of educational equity (i.e., equality of outcomes). Personalisation of learning is a process which considers the variability of the learner (learning strengths and challenges, beliefs, interests, motivation, context and culture), to design suitable learning scenarios and build a learning profile for each learner. i.e., what to teach, where to teach, when to teach, how to teach, how to learn and how to communicate with the learners.

AI technologies align with these paradigms by offering scalable solutions for learner-centred instruction. Through adaptive algorithms, intelligent tutoring systems, and predictive analytics, AI can support differentiated instruction, continuous assessment, and real-time feedback. These capabilities make AI an enabler of inclusive and equitable education.

3. Integrating AI with Personalised Learning

Personalised learning powered by AI (AI-PL) is rapidly being pursued to efficiently address the pedagogical and technological challenges. The underpinning mechanisms are based on

1. A learning analytics framework that observes learning activities in real-time,
2. A deep model incorporating a multi-channel representation of learning process embedding both knowledge and soft skills, and
3. A control model generating personalised recommendations to balance cognitive load, motivation, and collaboration level (E. August & Tsaima, 2021).

This system ensures equitable assessment of learning performance and engagement. Instructors receive context-aware intervention suggestions to upgrade the course proactively. There's no doubt therefore, that equity and access problems can mainly be surmounted using techcentred solutions like Artificial Intelligence besides teachers and classrooms. AI-based personalized learning provides the gift of access and equity by enabling personalized ondemand learning pathways based on abilities instead of age/stage. It leverages the ubiquity of mobile devices in Nigeria and other developing countries to get learning to students. A plethora of mobile devices and user-friendly content storage and sharing cloud platforms exist. Students will take marginal hours/lessons from their teachers and test their learning online to discover the areas they faltered. This gap can be shared with a wider network of teachers to check why the student is faltering in that area. To make it productive, all subsequent lessons in that particular area will then be presented only to that student scanned. Afterwards, more learning will continue. After some time of additional learning, the student will be retested.

Learning, modelling, and checking can all happen online. AI also avails an assembly of evaluation approaches that can detect learning problems that can be modelled and applied for formative purposes. The system can provide the details behind credits awarded ensuring traceability, auditability, and adjustability. These features of enabling integration of public, private, and alternative learning sources provide unrivalled added value in fulfilling the right to education and the provision of scalable support mechanisms. Recent updates include building a high-performance learning analytics system and interfaces for MOOCs (Massive Open Online Courses), flipped classrooms, interactive classrooms, and knowledge graphs. The AI-PL framework has been open-sourced to deliver a learning-friendly environment, and collaborations with external partners to apply the AI-PL framework in educational settings are ongoing.

Benefits of AI in Personalized Learning

Personalised learning platforms that apply AI techniques to both adapt and automate aspects of instruction (for teaching and assessment) offer powerful new modes of education. Such platforms make the delivery of education scalable in a wider range of settings and on a larger range of devices than traditional solutions. Properly implemented, these platforms have the capacity to address long-standing inequalities in access and quality of educational delivery globally, as brought on by poverty, geography, learning disabilities and other factors, and exacerbated by political, socio-economic and environmental factors.

Some of the numerous benefits of Personalised Learning, as implemented using AI are expatiated below:

Adaptive Content Delivery: AI systems adjust instructional materials in real-time based on student performance, allowing learners to progress at their own pace (Zawacki-Richter et al., 2019). This helps close learning gaps, especially in overcrowded classrooms or under-resourced schools.

Enhanced Engagement and Feedback: AI-driven tools like chatbots and intelligent tutors provide immediate feedback and support, increasing learner motivation and retention (Luckin et al., 2016).

Language and Accessibility: Natural Language Processing (NLP) enables AI tools to offer content in multiple languages and formats, including speech-to-text and audio for visually impaired learners (UNESCO, 2023). This is vital in linguistically diverse contexts and environments like Nigeria.

Scalability and Cost-Efficiency: Unlike traditional instruction models, AI solutions can be scaled across regions with minimal additional cost, potentially reaching millions of learners (World Bank, 2020). Once a database of pedagogical resources has been built, achieving further scaling and increasing the distribution network basically becomes a function of added infrastructure, and this is reasonably easier to manage.

Teacher Empowerment: AI can automate administrative duties such as grading and attendance, freeing up teachers to focus on pedagogy. It also offers professional development support through analytics and instructional recommendations (Holmes et al., 2019).

Case Studies and Global Practices

TheTeacher.ai: TheTeacher.ai is a personalized model developed for teacher training and on-going daily support. It is designed to provide instruction in an asynchronous and scalable manner. Teachers can either directly interact with the Teacher.AI for lesson planning, finding relevant materials, preparing classroom management or pedagogy prompts, generating comprehension questions, and gathering information about students. Teacher.AI is also designed to improve its suggestions based on teacher feedback.

Learning Passport: Nigeria's Ministry of Education launched the Learning Passport initiative in November 2020, working with (Bridget Azubuike et al., 2021). This initiative was piloted in three states – Lagos, Niger, and Kano and has progressed to other states. The investment leverages technology to deepen engagement in education delivery and create a framework for its effective use in both education and other domains. The platform has a working offline option that can be synched with a live data monitoring portal when internet access is restored. It is expected to reach even the remotest communities with learning materials, while also providing parents and non-education stakeholders cheaper options for understanding education delivery in Nigeria. All developed learning materials and functions within the Learning Passport meet international standards and are free of charge.

M-Shule (Kenya): M-Shule leverages AI and SMS technology to deliver personalized education to learners without internet access. To engage in effective learning It is designed to support marginalized learners using basic mobile phones (M-Shule, 2021).
uLesson (Nigeria) uLesson, a Nigerian EdTech company, uses AI-driven analytics to personalize tutoring services and assessments, adapting to learners' strengths and weaknesses in real-time (uLesson, 2022).

Squirrel AI (China): Squirrel AI employs machine learning to detect students’ cognitive weaknesses and recommend tailored content. It has shown significant improvements in learning outcomes, especially among struggling students (Zawacki-Richter et al., 2019).

Century Tech (UK): This platform combines neuroscience and AI to create personalized learning journeys. It supports both students and teachers by identifying learning gaps and recommending interventions. This technology could prove to be very helpful for learners with some difficulty like autism and dyslexia.

Challenges and Limitations to Implementation

There are multiple challenges that must be overcome to implement any effective AI-driven solution to enhance equitable access to education in Nigeria. These challenges range from the limitations related to AI systems themselves to social issues. Some of the challenges are elaborated on in the following subsections.

Infrastructure Deficits: Many regions in Nigeria lack reliable electricity and broadband, making digital learning inaccessible to large populations (Okoye & Adigwe, 2022).

Cost and Implementation Barriers: High initial investment in AI platforms, devices, and training poses a challenge for low-income schools and communities. The rapidly increasing cost of internet access also worsens this situation. Digital Literacy Gaps. Both educators and learners often lack the skills necessary to navigate AI-powered tools, which reduces the effectiveness of implementation.

Data Privacy and Ethics: AI tools collect large volumes of data, raising concerns about student privacy, data misuse, and algorithmic bias (Williamson & Eynon, 2020).

Cultural and Language Relevance: Most AI systems are developed in Western contexts. Without localization, they may fail to reflect the cultural and linguistic realities of African learners. People in resource-poor settings usually do not understand the idiomatic English that is used in educational materials and in speaking. This leads to incomplete comprehension of the material, and therefore to the view that one is not smart or educated enough to be able to think mathematically or scientifically. Therefore, knowledge-rich AI systems trained using data from education research in non-well-resourced settings, and potentially in languages other than English, are needed.

Ethical and Regulatory Considerations: AI in education must be guided by ethical frameworks that promote fairness, transparency, accountability, and inclusivity. Key concerns include:
Data Protection: Ensuring compliance with data privacy laws and ethical guidelines in data collection and storage.
Algorithmic Fairness: Avoiding biases in AI systems that may disadvantage certain student groups (Binns, 2018).
Transparency: Stakeholders must understand how AI systems make decisions affecting learner outcomes.
Participation: Learners, educators, and communities should be involved in the design and deployment of AI tools.
Governments must develop regulatory frameworks that govern the ethical use of AI in education and establish standards for procurement, evaluation, and accountability.
Strategies for Effective Implementation
Education content often requires expert delivery by trained professionals due to its complexity. Education delivery is thus brought to only a narrow set of those best positioned to teach it, limiting the overall pool of trained individuals, often reinforcing wealth and social inequalities in economically less fortunate areas (St-Hilaire et al., 2021).
Education content delivery via learning platforms can provide a more equitable solution for content distribution. Such a platform, accessed via a low-cost, internet-capable computer, could unhinge high quality educational content from its best-positioned deliverers, making it available to a much

wider subset of learners. This outcome of this effort can be further enriched by placing it in the hands of trained educators and researchers. This way, content could be better designed to foster understanding across a wider variety of learning scenarios (Jacoby et al., 2024).

Attention needs to be paid to a number of areas regarding the improved use of AI to implement personalized learning. This also means that the government must take steps to ensure that equitable access to financial resources, educational content, training, and ICT infrastructure is achieved. Whatever efforts the government makes will depend on the commitment and ability of its various arms to plan and implement meaningful interventions in these areas.

Stakeholder Engagement

Stakeholders in this initiative include students, teachers, and school administrators, as well as parents and guardians, the government, policy makers, and curriculum developers, learning management system providers, education NGOs, and the community broadly. Each of these stakeholder groups provide necessary and contextual support. For instance, students require parent engagement in their education, while teachers and school administrators require sensitivity from parents on issues affecting both students and teachers and on the need for teacher professional development. School administrators require support from the government and education NGOs such as effective supervision of schools and provision of school infrastructure, while curriculum developers require the support of the government and education NGOs. Platform integration developers require inputs from teachers and both understanding and participation from students. Studies have shown that high levels of stakeholder engagement lead to improved student outcomes (Chklovski et al., 2021). Partnering with stakeholders ensures the co-development of supported knowledge, thereby clarifying and situating their knowledge systems within the stratified educational system.

Training and Capacity Building

To enhance access and equity in education in Nigeria, the government, EdTech Product developers, entrepreneurs, and the private sector must continuously train and build the capacity of educators, facilitators, and stakeholders in educational technology.

This constant upskilling provides opportunities to learn new EdTech pedagogies, contents, tools, new teaching strategies, and techniques, among others.

Training on EdTech for teacher in Nigeria is still erratic, especially in the public schools, resulting in another digital divide where only a selected group of teachers have access to basic digital literacy training. Educators should be able to design their training, capacity-building meetings, and inhouse trainings through free webinars, short courses, and Massive Open Online Platforms (MOOCs) using EdTech tools.

Policy Recommendations

To harness the potential of AI and personalized learning for educational equity, the following strategies are recommended:

1. Infrastructure Investment: Expand internet access and electricity to rural and underserved communities.
2. Teacher Training: Integrate digital literacy and AI skills into teacher education programs. A major key to enhancing the quality of education provided through ICT is a rapidly consistent teacher training and re-evaluation to optimize new engagements with the solution.
3. Localization of Content: Develop AI systems that reflect local languages, cultures, contexts and curriculum.

4. Public-Private Partnerships (PPPs): Encourage collaboration between government, tech firms, and civil society to scale solutions. This can create collaborative synergy and drive scalable AI innovations, merging ideas and resources to build scalable initiatives that benefit society as a whole. Through this commitment, companies, communities, local, state and national governments, and non-profits can converge their time, talent, and wealth to work together for the systemic and sustainable improvement of education and learning.
5. Monitoring and Evaluation: Establish benchmarks and indicators for tracking the impact of AI-powered learning interventions.

Future Directions, Innonations and Scaling Potentials

As the international landscape evolves, there will be increased calls for personalised learning (PL) approaches that prioritize equity and access in education across multiple geographies. However, the value propositions of personalised learning (PL) have not yet been fully unpacked and blended with culturally sophisticated elements for students across diverse geographies. As high-quality PL approaches are redeveloped, there will be continued exploration into the feasibilities and tradeoffs of PL approaches across different epistemologies, learning demands, educational pathways, and technology infrastructure.

Affective computing can also be employed to support personalized learning to provide an opportunity to tap into human characteristics that have not been widely discussed, including the usage of facial recognition software to capture feelings and other psychological and physiological traits.

There will be a need for rigorous, independent, quantitative, mixed-method, and longitudinal studies that unpack how technologies make a difference in education across varying contexts and cultures, with an explicit focus on potential consequences.

Innovative approaches, such as cloud-based technologies, have gained immense traction among educational innovations in developing economies, allowing greater access, broader coverage, and lower costs.

Conclusion

Educational disparities in Nigeria are wide-ranging and include regional imbalances, socioeconomic disparities, differences in school infrastructure and materials, lack of adequately trained teachers, and poor financing. These disparities manifest in unequal access to education, poor retention rates, low completion rates, and waning quality. The dividend of education, in terms of social and economic benefits, equity, and social justice cannot be fully realized unless these disparities are addressed.

The use of AI in personalized learning offers a powerful avenue to address educational disparities and promote access and equity in learning. While challenges remain, especially regarding infrastructure, cost, and ethics, the strategic and inclusive deployment of AI can reshape education in Nigeria and beyond. With sound policy, localized implementation, and collaborative innovation, AI can democratize learning, empower educators, and create more inclusive features for all learners.

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PRE-SERVICE TEACHERS' ATTITUDE TOWARDS THE USE OF E-PORTFOLIO IN ADEYEMI FEDERAL UNIVERSITY OF EDUCATION, ONDO

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Abstract

This study explores the attitudes of pre-service teachers towards the use of e-portfolios in their learning at Adeyemi Federal University of Education, Ondo. E-portfolios, which are digital platforms that allow students to document, reflect on, and showcase their academic progress and professional development, are increasingly being adopted in teacher education. Three hundred and forty-four (344) students were selected for the study out of the five hundred and seven (507) total population of students in the Faculty of Education. Three research purposes, three research questions and one research hypothesis were raised for this study. The reliability of the instrument was examined using Cronbach's Alpha and it yielded 0.83 value. Descriptive survey analysis was employed with the use of mean, standard deviation and T-test to analyse the data collected through self-designed online questionnaire. Based on the results of the analysis of data, findings reveal generally positive attitudes towards e-portfolios, recognizing their value in enhancing reflective learning and professional growth. However, challenges such as the need for improved technical support, better training, and time management were identified. The study therefore recommended enhanced training and workshops on e-portfolio usage, improved technical support, deeper integration of e-portfolios into the curriculum, and continuous feedback from instructors to maximize the benefits of e-portfolios in teacher education.

Keywords: Pre-service Teacher, E-Portfolio, Perception, Learning, Digital platforms

Introduction

According to Abrami, *et al* (2013) defines electronic portfolio as a digital container capable of storing visual and auditory content, including text, images, video, and sound. Electronic portfolio is an alternative assessment tool for teaching and learning. In short, E-Portfolio permits a way to measure "students' achievements by their ability to create tangible products exemplifying their accomplishments in terms of analysis, synthesis, and evaluation" (Molenda, 2018). E-Porfolio is also used as a self-assessment tool for the professional development of pre-service and in-service teachers in different content areas (Silva & Park, 2015). Further, as a self-assessment tool for learning, E-Portfolio serves as a foundation for documenting the acquisition of skills and knowledge over time.

Teacher education programs have adopted E-Portfolio, which is used in managing, assessing, and demonstrating learning of teacher education candidates (Larsen, Park, & Tai, 2015). A survey conducted by the Annual Association for Authentic Experiential Evidence-Based Learning shows that 50% of educational departments in the United States and 400 colleges have provided financial support for programs relating to the development of E-Portfolio in teacher education programs (Wuetherick & Dickinson, 2015). E-Portfolio has been demonstrated as an effective tool in pre-service teacher education and for the continued professional development (Smaldino & Russell, 2018). Therefore, E-portfolios are widely used in educational settings to showcase student work, facilitate self-reflection, and support assessment. In conclusion, while e-portfolios offer significant benefits for enhancing learning, reflection, and assessment in teacher education programs, they also present various challenges which need to be addressed. Such challenges includes technical issues, providing thorough training and ongoing support, managing time constraints, aligning with curricular goals, ensuring privacy and ethical standards, maintaining consistency, and overcoming resistance to change are all crucial for their successful implementation. By strategically addressing these challenges, institutions like university can harness the full potential of e-portfolios to enrich the educational experience, promote professional growth, and better prepare future educators for their careers.

According to Abrami, Venkatesh, Meyer, and Wade (2013) defines electronic portfolio as a digital container capable of storing visual and auditory content, including text, images, video, and sound. EPs may also be learning tools not only because they organize content but also because they are designed to support a variety of pedagogical processes and assessment purposes. In short, E-Portfolio permits a way to measure “students’ achievements by their ability to create tangible products exemplifying their accomplishments in terms of analysis, synthesis, and evaluation” (Smaldino, Russell, Heinich, & Molenda, 2018). Teachers frustrated with more conventional assessment methods have turned toward electronic portfolios to evaluate learning as “a truer, more rounded view of an individual’s strengths and weaknesses” (Smaldino, Russell, Heinich, & Molenda, 2018). ePorfolio has been widely used in online education as a learning enhancement tool to store and showcase individual achievement for almost two decades (Girish, Issack, & Ravindra, 2021). ePorfolio is also used as a self-assessment tool for the professional development of pre-service and in-service teachers in different content areas (Masari, 2013). Further, as a self-assessment tool for learning, ePortfolio serves as a foundation for documenting the acquisition of skills and knowledge over time (Huang, Yang, & Chang, 2021).

In recent years, technological advancements have significantly transformed various aspects of education, including teaching, learning, and assessment. One notable innovation in education technology is the adoptions of e-portfolios, which are electronic platforms that allow individuals to collect, organize, and present evidence of their learning and accomplishments. E-portfolios offer a dynamic and interactive way for students to showcase their skills, experiences, and reflections. They have gained popularity in educational settings globally due to their potential to enhance self-directed learning, facilitate assessment, and promote reflective practice (Wuetherick & Dickinson; 2015). Electronic portfolio or ePortfolio is an alternative assessment tool for teaching and learning. The E-Portfolio helps display or demonstrates one’s learning achievements and outcomes across a set time period. Compared to traditional forms of assessment such as papers, examinations, and projects, E-Portfolio represents the learner’s achievements that demonstrate what has been learned, gained, acquired, or felt toward a topic area (Silva, *et al.* 2015).

In the Nigerian educational context, the adoption of e-portfolios among pre-service teachers presents both opportunities and challenges. Understanding the attitudes of these future educators towards e-portfolios is essential for effectively integrating this technology into teacher education curricula. Research suggests that students' attitudes towards technology can significantly influence their adoption and utilization of digital tools (Teo, 2009). Teacher education programs have adopted ePortfolio, which is used in managing, assessing, and demonstrating learning of teacher education candidates (Fan & Reynolds, 2014; & Tai, 2015). A survey conducted by the Annual Association for Authentic Experiential Evidence-Based Learning shows that 50% of educational departments in the United States and 400 colleges have provided financial support for programs relating to the development of ePortfolio in teacher education programs (Britten, Mullen, & Stuve, 2003). ePortfolio has been demonstrated as an effective tool in pre-service teacher education and for the continued professional development beyond the university classroom (Boulton, 2014; Buyarski & Landis, 2014; Carson, McClam, Frank, & Hannum, 2014).

Statement of Problem

Electronic portfolio as a digital container capable of storing visual and auditory content, including text, images, video, and sound. Electronic portfolio is an alternative assessment tool for teaching and learning. Despite the increasing adoption of e-portfolios in higher education globally, there is a gap in knowledge in its adoption and utilization among the pre-service teachers in Adeyemi Federal University of Education Ondo. This study therefore investigated the pre-service teachers' attitude towards the use of E-portfolio in Adeyemi Federal University of Education, Ondo.

Objectives of the Study

The objectives of the study are to:

1. assess pre-service teachers' attitudes towards the use of e-portfolios.
2. identify factors influencing pre-service teachers' attitudes towards e-portfolios.
3. explore the challenges associated with the use of e-portfolios in teacher education programs.

Research Question

1. What are the pre-service teachers' attitudes towards the use of e-portfolios at AFUED?
2. What are the factors influencing pre-service teachers' attitudes towards e-portfolios?
3. What are the challenges associated with the use of e-portfolios in teacher education programs?

Research Hypothesis

H_{01}: There is no significant difference in pre-service teachers' attitude towards the use of e-portfolio at AFUED based on gender.

Methodology

A descriptive survey design was employed for the study. The population consisted three hundred and forty-four (344) out of the total population of five hundred and seven (507) students in the Faculty of Education. To give all the four departments an equal opportunity, a random sampling technique was adopted to select forty (86) respondents from each of them regardless of their gender. The instrument used in this study was self-designed questionnaire on Likert four-point scales. The questionnaire had two sections A and B, section "A" was concerned with demographic information while section "B" sought to investigate "Pre-service Teachers' Attitude Towards the Use of E-Portfolio in Adeyemi Federal University of Education, Ondo. PTATUEP". Copies of the questionnaire were validated by three (3) experts in Educational Technology for face and content validity of the instrument. The questionnaire was tested for reliability on fifty (50) randomly selected students in University of Medical Sciences, Ondo who are not part of the study. The data gathered from the pilot study was analyzed to check for internal consistently of reliability at the Cronbach alpha value of 0.83. This value indicated that the research instrument was highly reliable. At the end of the exercise, analyses of the results were carried out. Mean, standard deviation and t-test were used to analyze the data collected with the decision Value: Low = 0.00-2.44, High = 2.45-4.00.

Result

Research Question1: What are the pre-service teachers' attitudes towards the use of E-portfolios at AFUED?

Table 1: *Pre-Service Teachers' Attitudes towards the Use of E-portfolios*

Item	SA	A	D	SD	Mean	Std. D
Electronic portfolio can be defined as a digital container capable of storing visual and auditory content, including text, images, video, and sound.	191	199	34	0	3.46	.67
Using of E-portfolios motivates many pre-service teachers to engage more deeply with their assignments and projects.	181	120	43	0	3.40	.70
E-portfolios contribute to pre-service teachers' overall growth and development as a future educator.	259	77	8	0	3.73	.49
E-Portfolio permits a way to measure students' achievements by their ability to create tangible products exemplifying their accomplishments in terms of analysis, synthesis, and evaluation	96	248	0	0	3.28	.45
E-portfolios provide a better way to showcase teachers' skills and achievements compared to traditional methods.	139	178	27	0	3.33	.61
With the use of E-portfolios, students enhance more learning experience.	24	293	27	0	2.99	.39
Weighted Average					**3.37**	

Key; *SD* = Strongly Disagree, **D =** Disagree, **A =** Agree, **SA =** Strongly Agree
Decision Value: ***Negative***=0.00-2.49, ***Positive*** = 2.50-4.00

Table 1 shows the pre-service teachers' attitudes towards the use of E-portfolios. The table shows that the students agreed to all the items as follows: electronic portfolio is a digital container capable of storing visual and auditory content, including text, images, video, and sound($\bar{x}$ = 3.46), using of E-portfolios motivates many pre-service teachers to engage more deeply with their assignments and projects ($\bar{x}$ = 3.40), E-portfolios contribute to pre-service teachers' overall growth and development as a future educator($\bar{x}$ = 3.73), E-Portfolio permits a way to measure students' achievements by their ability to create tangible products exemplifying their accomplishments in terms of analysis, synthesis, and evaluation($\bar{x}$ = 3.28),E-portfolios provide a better way to showcase teachers' skills and achievements compared to traditional methods($\bar{x}$ = 3.33), and with the use of E-portfolios, students enhance more learning experience ($\bar{x}$ = 2.99). Meanwhile, based on the value of the weighted average (3.37 out of 4.00 maximum value obtainable) which falls, within the decision value for ***positive,*** it can be inferred that the pre-service teachers' attitudes towards the use of E-portfolios at AFUED is positive.

Research Question2: What are the factors influencing pre-service teachers' attitudes towards e-portfolios?

Table 2:

Factors Influencing Pre-Service Teachers' Attitudes Towards the use of E-Portfolios

Item	SA	A	D	SD	Mean	Std. D	Remark
The usability of the E-portfolio platform influences teachers' attitude towards its use.	160 183	161	0	0	2.53	.49	Accepted
The integration of E-portfolios into my coursework influences my attitude towards their use.	72	170	83	19	2.86	.81	Accepted
The amount of time required to maintain an E-portfolio affects most of the teachers' attitude towards its use.	198	121	25	0	3.50	.63	Accepted
The availability of technical support impacts pre-service teachers' willingness to use E-portfolios.	102	146	96	0	3.02	.76	Accepted

Key; *SD* = Strongly Disagree, **D =** Disagree, **A =** Agree, **SA =** Strongly Agree

Decision Value for Remark:*Not Accepted*=0.00-2.44, ***Accepted*** = 2.45-4.00

Table 2 shows the factors influencing pre-service teachers' attitudes towards e-portfolios. The table shows that the students agreed to all the items as follows: usability of the E-portfolio platform influences teachers' attitude towards its use($\bar{x}$ = 2.53), integration of E-portfolios into my coursework influences my attitude towards their use ($\bar{x}$ = 2.86), the amount of time required to maintain an E-portfolio affects most of the teachers' attitude towards its use($\bar{x}$ = 3.50) and availability of technical support impacts pre-service teachers' willingness to use E-portfolios ($\bar{x}$ = 3.58). Based on the result from this table and mean score acceptance by the decision rule, the factors influencing pre-service teachers' attitudes towards e-portfolios are: the usability of the E-portfolio platform influences teachers' attitude towards its use, integration of E-portfolios into their coursework influences their attitude towards their use, the amount of time required to maintain an E-portfolio affects most of the teachers' attitude towards its use and availability of technical support impacts pre-service teachers' willingness to use E-portfolios.

Research Question3: What are the challenges associated with the use of E-portfolios in teacher education programmes?

Table 3:Challenges Associated with the Use of E-Portfolios in Teacher Education

Item	SA	A	D	SD	Mean	Std. D	Remark
Integrating multimedia elements effectively is one of challenges associated with the use of E-portfolios in teacher education programme.	191	91	62	0	3.37	.77	Accepted
The time required to create and maintain E-portfolios serve asa significant challenge for teacher education programme.	173	109	35	27	3.24	.93	Accepted
Most technical issues, such as software compatibility and internet access, pose a major challenge in the use of E-portfolios in teacher education programme.	163	127	27	27	3.24	.90	Accepted
Most of the institutions found difficulty in fostering student engagement and motivation to use E-portfolios effectively.	197	70	69	8	3.33	.87	Accepted
Lack of adequate training for students on how to effectively use E-portfolios in teacher education programs.	68	128	146	2	2.76	.77	Accepted

Key; *SD* = Strongly Disagree, **D =** Disagree, **A =** Agree, **SA =** Strongly Agree
Decision Value for Remark: ***Not Accepted***=0.00-2.44, ***Accepted*** = 2.45-4.00

Table 3 shows the potential challenges associated with the use of E-portfolios in teacher education programmes. The table shows that the students agreed to all the items as follows: integrating multimedia elements effectively is one of challenges associated with the use of E-portfolios in teacher education programme($\bar{x}$ = 3.37), time required to create and maintain E-portfolios serve as a significant challenge for teacher education programme ($\bar{x}$ = 3.24), most technical issues, such as software compatibility and internet access, pose a major challenge in the use of E-portfolios in teacher education programme ($\bar{x}$ = 3.24),Most of the institutions found difficulty in fostering student engagement and motivation to use E-portfolios effectively($\bar{x}$ = 3.24),and lack of adequate training for students on how to effectively use E-portfolios in teacher education programs ($\bar{x}$ = 2.76). Based on the result from this table and mean score acceptance by the decision rule, the potential challenges associated with the use of E-portfolios in teacher education programmes are: integrating multimedia elements effectively, time required to create and maintain E-portfolios, technical issues, such as software compatibility and internet access, Most of the institutions found difficulty in fostering student engagement and motivation to use E-portfolios effectively, and lack of adequate training for students on how to effectively use E-portfolios in teacher education programs.

Hypothesis Testing

Ho1: There is no significant difference in pre-service teachers' attitude towards the use of e-portfolio at AFUED based on gender.

Table 4:*Summary of T-test Showing Difference in Male and Female Pre-Services Teachers 'Attitude towards the Use of E-Portfolio*

Grouping Variable (Gender)	N	Mean	Std. D	Df	T	Sig.	Remark
Male	155	20.26	1.15	342	1.122	.262	Not Significant
Female	189	20.12	1.09				

Table 4 shows the difference in the attitudes of male and female lecturers towards the use of e-portfolios in Adeyemi Federal University of Education, Ondo. The table shows that the mean score for male pre-service teachers is20.26 while that of female is 20.12. The values of the mean scores do not reveal an appreciable difference. Therefore, there is no significant difference in pre-service teachers' attitude towards the use of e-portfolio at AFUED based on gender (df = 342; t = 1.122; $p > 0.05$). Hence, hypothesis 1 is not rejected. This result implies that the attitude of male and female pre-service teachers towards the use of e-portfolio is same.

Discussion of Findings

The finding that pre-service teachers at AFUED have a positive attitude towards the use of e-portfolios is consistent with several studies that highlight the benefits of e-portfolios in teacher education. Research by Driessen et al. (2017) emphasizes that e-portfolios enhance reflective practices and support continuous professional development. Additionally, Barrett (2019) argues that e-portfolios encourage students to take ownership of their learning, which can contribute to positive attitudes. The positive reception at AFUED could be attributed to these perceived benefits, aligning with the broader educational trend that views e-portfolios as a valuable tool for both learning and assessment. The challenges identified in the study, such as multimedia integration, time requirements, technical issues, student engagement, and lack of training are well-documented in the literature. Van Wyk (2017) discusses how the time-consuming nature of e-portfolios can be a barrier, especially when students lack the necessary technical skills. The study further notes that technical challenges, such as software compatibility and internet access, can frustrate both students and educators, reducing the effectiveness of e-portfolios. The difficulty in maintaining student engagement is echoed in Buzzetto-More (2010), who stresses the need for engaging and interactive content to sustain students' interest in using e-portfolios. The finding that there is no significant difference in attitudes based on gender and the lack of gender differences might suggest that both male and female students perceive the value of e-portfolios similarly, which is consistent with findings by Buzzetto-More and Alade (2018), who found no significant gender differences in e-portfolio adoption and attitudes.

Conclusion

The research concludes that pre-service teachers at Adeyemi Federal University of Education generally have a positive attitude towards the use of e-portfolios, recognizing their value in promoting reflective practice, self-assessment, and professional development. However, several challenges were identified, including the need for more comprehensive technical support, better training on effective e-portfolio use, and addressing concerns about the time commitment required to maintain them. Moreover, while e-portfolios are viewed as useful tools for showcasing achievements, some pre-service teachers expressed concerns about potential biases in assessment and the need for clearer guidelines on e-portfolio usage. Addressing these concerns is crucial to maximizing the benefits of e-portfolios in teacher education (Hallam & Creagh, 2010).

Recommendations

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

1. To improve the effective use of e-portfolios, it is recommended that the university offers comprehensive training sessions and workshops for pre-service teachers.
2. The University should ensure that adequate technical support is available to assist pre-service teachers in navigating any difficulties they encounter while using e-portfolios.
3. E-portfolios should be more deeply integrated into the curriculum, with clear guidelines and assessment criteria provided to ensure that pre-service teachers understand the expectations and can effectively use e-portfolios to demonstrate their learning and professional growth.
4. To enhance the effectiveness of e-portfolios, instructors should provide continuous and constructive feedback on students' e-portfolios, helping them to improve their work and better understand how to use the tool for their professional development.
5. The University should consider ways to help pre-service teachers manage the time required to maintain their e-portfolios, perhaps by integrating e-portfolio work into existing assignments or by providing time management resources.

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ROLES OF PRE-RECORDED VIDEO RESOURCES TO IMPROVE MICROTEACHING COMPETENCE AMONG PRE-SERVICE TEACHERS IN NIGERIA

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Abstract
This paper examines the potential of pre-recorded video resources to enhance microteaching competence among pre-service teachers in Nigeria. Microteaching remains a cornerstone of teacher education, offering structured opportunities for the rehearsal and refinement of pedagogical skills. However, traditional approaches are often constrained by limited contact hours, inconsistent feedback mechanisms, and restricted access to exemplary teaching models. Grounded in constructivist and cognitive multimedia learning theories, this paper explores how pre-recorded instructional videos which featuring expert demonstrations, peer-led sessions, and reflective commentaries can supplement conventional microteaching practices. Als, enabling repeated viewing, facilitating self-paced learning, and fostering critical reflection, such resources support the development of core teaching competencies including instructional planning, classroom communication, and professional self-awareness. Through a synthesis of current literature and theoretical insights, the paper proposes a conceptual framework for integrating video-based tools into teacher preparation programs. It concludes with key implications for curriculum designers, teacher educators, and policy actors, advocating for strategic investment in digital infrastructure and pedagogical training to fully harness the affordances of video-enhanced microteaching. It is recommended that teacher education institutions adopt a blended microteaching model that incorporates curated pre-recorded video content alongside live practice sessions to optimize training outcomes and promote reflective teaching practices.

Keywords: Microteaching, Pre-service Teachers, Pre-recorded Video, Teacher Education, Instructional Technology

Introduction
The global push toward improving the quality of education has placed teacher preparation at the forefront of educational reform, particularly in developing countries like Nigeria. At the heart of teacher education is microteaching, a pedagogical approach that offers structured, scaffolded practice opportunities for pre-service teachers to develop and refine essential teaching competencies (Maguire, 2023). Microteaching typically involves the design and delivery of short teaching segments, followed by feedback and reflection, thus promoting a deliberate focus on discrete teaching skills such as questioning, classroom management, lesson delivery, and communication. Despite its pedagogical strengths, microteaching in many Nigerian colleges of education and universities is often constrained by structural and operational limitations, including overcrowded classes, limited contact hours, insufficient feedback loops, and the absence of access to high-quality teaching models (Yusuf, & Ibrahim, 2024).
In response to these challenges, researchers and practitioners have begun to explore the use of pre-recorded video resources as a complementary tool to traditional microteaching. Pre-recorded instructional videos that featured expert demonstrations, peer-led teaching sessions, and reflective

narratives which offer an innovative means of enhancing teaching competence among pre-service teachers. These resources allow for repeated exposure to exemplary teaching, self-paced learning, and enhanced opportunities for reflection, thereby addressing the time and feedback limitations of traditional microteaching formats (Torres, 2024). Importantly, such resources can also bridge the gap between theory and classroom practice, providing visual and contextual models that enhance learning transfer and pedagogical reasoning (Phillips, H& Condy, 2023).

The integration of video resources in teacher education is grounded in sound theoretical principles. From the constructivist learning perspective (Vygotsky, 1978), learners actively construct knowledge through observation, interaction, and reflection. When pre-service teachers engage with teaching videos, they are not merely passive viewers but active interpreters who make meaning from practice examples, reflect on instructional choices, and adapt them to personal teaching contexts. Additionally, Mayer's (2021) updated Cognitive Theory of Multimedia Learning provides empirical grounding for the integration of visual and verbal modes in instructional design. According to this theory, video-based materials enhance learning by reducing cognitive overload, directing attention to key pedagogical moves, and supporting dual-channel processing.

Recent empirical evidence supports the effectiveness of video-enhanced learning in teacher education. For instance, Gachowski, (2025) found that pre-service teachers who engaged with curated teaching videos showed improved classroom performance, deeper reflection, and stronger instructional planning skills compared to their peers in traditional microteaching-only formats. Similarly, Schlosser, and Paetsch, (2023) demonstrated that the use of reflective video analysis improved teaching self-efficacy, particularly in lesson delivery and classroom questioning techniques. In Nigeria, where disparities in resource access and training quality persist, video-based tools represent a scalable solution that can democratize access to expert teaching models and create more equitable learning environments (Dahlan, et al., 2023).

Given these promising developments, this paper explores the conceptual roles of pre-recorded video resources in improving microteaching competence among Nigerian pre-service teachers. The paper synthesizes current literature, theoretical insights, and contextual challenges to propose a conceptual framework for integrating video-based strategies in teacher preparation programs. It further outlines practical implications for curriculum designers, teacher educators, and educational policymakers, recommending a blended microteaching model that leverages both live teaching practice and strategically curated video content. The ultimate aim is to offer a roadmap for optimizing microteaching outcomes and fostering reflective, adaptive, and competent educators for the 21st-century classroom.

Conceptual Definitions of Terms

To fully understand the role of pre-recorded video resources in enhancing microteaching competence among pre-service teachers, it is essential to clarify the key concepts underpinning this study. These concepts include *microteaching*, *pre-recorded video resources*, *microteaching competence*, and the *blended microteaching model*. Defining these terms provides a clear framework for the discussion and guides the integration of theory and practice in the research.

Microteaching

Microteaching is a scaled-down teaching simulation designed to provide pre-service teachers with an opportunity to practice and refine specific teaching skills in a controlled, supportive environment (Zhang, et al., 2024). Unlike full classroom teaching, microteaching typically involves teaching a brief lesson segment (usually 5–10 minutes) to a small group of peers or students, followed by feedback and reflection. It is widely acknowledged as an effective method for developing foundational teaching skills such as lesson planning, questioning techniques, classroom management, and verbal and non-verbal communication (Ogunleye & Adeoye, 2020). The microteaching cycle which include plan, teach, observe, feedback, and re-teach—emphasizes iterative improvement and reflective practice, which are vital for developing teaching proficiency.

Pre-recorded Video Resources

Pre-recorded video resources refer to audiovisual materials created in advance that demonstrate teaching practices, pedagogical strategies, or instructional content relevant to teacher education. These videos can include expert teaching demonstrations, peer microteaching sessions, annotated lessons, and reflective commentaries that highlight effective instructional techniques or common challenges (Seidel et al., 2013). The use of such videos in teacher education facilitates self-paced learning, enabling pre-service teachers to watch, analyze, and reflect on teaching episodes multiple times, thereby deepening their understanding and self-awareness. Moreover, videos serve as concrete exemplars that help bridge the gap between theory and practice, especially in contexts where live demonstrations or diverse classroom experiences are limited (Yusuf et al., 2021).

Microteaching Competence

Microteaching competence encompasses the knowledge, skills, attitudes, and reflective capacities that pre-service teachers develop through engaging with microteaching activities. It includes the ability to effectively plan lessons, deliver instruction clearly, manage the classroom environment, use questioning techniques to stimulate student thinking, and engage in critical self-evaluation and peer feedback (Gambari et al., 2022). Competence in microteaching is not merely about mastery of isolated teaching skills but also the integration of these skills into coherent and adaptive instructional practices. This competence is foundational for successful transition into real classroom teaching.

Blended Microteaching Model

The blended microteaching model integrates traditional face-to-face microteaching sessions with digital enhancements, particularly the use of pre-recorded video resources (Obielodan & Adebayo, 2023). This model recognizes that while live microteaching offers immediate practice and feedback opportunities, video resources provide flexibility, repeated exposure, and richer reflection opportunities. Blended microteaching enables pre-service teachers to prepare better before live sessions by studying exemplar videos, engage in self-assessment through video review of their own teaching, and participate in asynchronous discussions about teaching practices. Such integration leverages the strengths of both approaches to optimize teacher preparation outcomes.

Theoretical Framework

The theoretical framework provides the foundation for understanding how pre-recorded video resources can enhance microteaching competence among pre-service teachers. This study is anchored primarily in two complementary theories: Constructivist Learning Theory and Cognitive Theory of Multimedia Learning. Together, these theories explain the cognitive and social processes through which pre-service teachers learn and internalize teaching competencies via video-enhanced microteaching.

Constructivist Learning Theory

Constructivism, rooted in the works of Vygotsky (1978) and Piaget (1954), posits that learners actively construct knowledge through experience, reflection, and social interaction. In this perspective, learning is not a passive absorption of information but a dynamic process where learners build understanding by linking new knowledge to prior cognitive structures and engaging with authentic tasks. Vygotsky's concept of the **Zone of Proximal Development (ZPD)** is particularly relevant in teacher education, emphasizing the importance of scaffolding and guided practice to help learners accomplish tasks slightly beyond their current capabilities (Vygotsky, 1978).

In the context of microteaching, constructivism supports the use of pre-recorded video resources as tools that enable pre-service teachers to observe authentic teaching scenarios, reflect critically on pedagogical strategies, and engage in self-regulated learning. Videos provide rich contextualized content that learners can analyze repeatedly, thus promoting deeper conceptual understanding. Moreover, video-based peer discussions and reflections foster social interaction, enabling learners to co-construct knowledge collaboratively

Cognitive Theory of Multimedia Learning

Richard Mayer's Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2021) provides a cognitive explanation for why video resources are effective in enhancing learning outcomes. Mayer argues that humans process information through two channels: the auditory/verbal channel and the visual/pictorial channel. Learning is maximized when these channels work together to build coherent mental representations. However, cognitive resources such as attention and working memory are limited, so instructional design must manage cognitive load to prevent overload.

Pre-recorded instructional videos, if well-designed, support dual-channel processing by combining verbal explanations with visual demonstrations, thus facilitating deeper learning. For pre-service teachers, seeing an expert model teaching strategies visually while simultaneously hearing explanations helps integrate procedural knowledge with conceptual understanding. The ability to pause, rewind, and reflect on video content further reduces cognitive load and encourages active engagement with the material (Mayer, 2021).

Moreover, CTML highlights several principles relevant to video use in microteaching: the modality principle (combining spoken words with visuals), the segmenting principle (breaking content into manageable chunks), and the reflection principle (encouraging learners to pause and think). These principles underpin effective video design that scaffolds pre-service teachers' acquisition of teaching competencies.

Integration of Theories in Video-Enhanced Microteaching

The combination of constructivist and multimedia learning theories offers a comprehensive framework for the integration of pre-recorded video resources into microteaching. Constructivism emphasizes the learner's active role in constructing knowledge through reflection and social interaction, which is supported by video-based observation and collaborative analysis. CTML explains the cognitive mechanisms by which multimedia presentations in videos enhance understanding and retention of teaching skills.

This integrated theoretical perspective suggests that video-enhanced microteaching can promote meaningful learning by providing authentic teaching models (constructivism) and optimizing cognitive processing through multimedia design (CTML). Pre-service teachers can observe, analyze, and reflect on teaching episodes multiple times, internalize pedagogical strategies, and apply them in their own microteaching sessions. This approach encourages self-regulated learning, reflective practice, and iterative improvement, all crucial for developing microteaching competence.

Empirical Studies on Pre – recorded video instruction

Onal (2019) conducted a study on an exploratory study on pre-service teachers' reflective reports of their video-recorded microteaching. In this study, the participating pre-service teachers were asked to video- record their microteaching performances and watch their performances several times before they write a reflective report on their performance. The technique of content analysis was applied in the analysis process of the reflective reports and their perceptions as to their instructional skills have been identified. It has also been observed that, in comparison to traditional implementation of the microteaching technique, integration of smartphone video- recording technology into the microteaching technique yielded benefits particularly in terms of the feedback stage and improving pre-service teachers' reflective skills.

Vega et al. (2021) conducted a study to design and validate a model of teaching competencies in Virtual learning Environment, with the support of virtual laboratories, to ensure the quality of higher education during the covid-19 pandemic. A quantitative and correlational methodology was used in a case study. The research was divided into two methodological moments: the design of the model and its validation. The instruments used were a comparative analysis matrix and a Likert-type scale. 5 650 students and 41 teachers participated in the validation cap. The results highlight the need for teacher development, mainly in digital and research skills. One weakness of the study is the lack of weighting of the quality indicators. The proposed model represents an innovation in the definition of indicators, in the form of competencies, for the assurance of educational quality in Virtual learning Environment. It is concluded that the proposed model is pertinent for the assurance of educational quality in Virtual learning Environment

Bakri et al. (2022) investigated the learning level of students based on their perceptions. An online self-administered questionnaire was disseminated to students from three campuses of UiTM Sarawak (Samarahan, Samarahan 2, and Mukah). Data obtained from a sample of 1199 students was analyzed using descriptive statistics to measure students' perception of the method that they preferred. The resultsshow that the mixed delivery method was the most preferred method among students for online learning, which accounted for 63.9%. This was followed by 28.7% of the students who preferred pre-recorded video lecture because it is more flexible and the remaining 7.4% of the students preferred live lecture because of the higher level of interactions and greater ability to concentrate. Live lecture and pre-recorded video were found to suit each other depending on students' time. These findings are beneficial to the learning institutions in providing better services to students through open and distance learning.

Lim et al. (2024) compared students' preferences for pre-recorded videos and live lectures, and to establish the relationship between these two types of online lectures on students' online learning satisfaction and academic achievement during the pandemic. This study is quantitative in nature and involved 552 respondents who are undergraduate students from four faculties in one of the private universities in Malaysia. Structural Equation Modeling (SEM) was used to analyse the proposed hypotheses. The results show that the pre-recorded video lecture has a positive effect on students' online learning satisfaction in three faculties, i.e., Social Science, Business and Medical Science, whereas, in the faculty of Innovation and Technology, the live online lecture has a significant effect on their students' online learning satisfaction. However, students from all four faculties responded that both pre-recorded video lectures and live online lectures did not significantly improve their academic achievement. The findings of this study provide a guideline for academics in their online pedagogical consideration, especially in deciding the type of online lecture preferred by their students which has contributed to their online learning satisfaction, thus improving the overall quality of the online learning experience.

Components of Pre-recorded Video Resources

Pre-recorded video resources are multi-dimensional instructional tools that can significantly enhance microteaching by offering pre-service teachers diverse ways to observe, analyze, and reflect on teaching practices. To maximize their impact on microteaching competence, these video resources typically comprise several key components. Understanding these components helps in designing, curating, and integrating video materials effectively within teacher education programs.

1. Expert Demonstration Videos: One of the most critical components is expert demonstration videos. These videos showcase experienced educators delivering lessons, modeling best pedagogical practices, and effectively managing classroom interactions. Expert demonstrations provide concrete examples of instructional strategies, lesson structure, questioning techniques, and classroom management approaches. Pre-service teachers can observe not only what is taught but also how it is taught, including tone, body language, pacing, and responsiveness to students (Seidel et al., 2013). This component serves as a reference model that guides learners in understanding professional standards and effective teaching behaviors.
2. Peer-led Microteaching Recordings: Another vital component includes peer-led microteaching recordings, which are videos of fellow pre-service teachers conducting microteaching sessions. These peer recordings allow learners to critically analyze their colleagues' teaching methods and receive feedback on their own recorded teaching. Watching peer videos promotes comparative reflection, enhances critical thinking, and fosters a sense of collaborative learning (Sherin & van Es, 2009). It also creates opportunities for pre-service teachers to recognize common challenges and diverse approaches to similar instructional tasks.
3. Reflective Commentaries and Annotations: Reflective commentaries and annotations embedded in or alongside the videos provide guided prompts, explanations, and expert feedback to deepen understanding. These may include voiceovers highlighting key teaching moves, text overlays pointing out effective strategies, or video pauses encouraging viewers to reflect on specific teaching moments (Obielodan & Adebayo, 2023). This scaffolding supports learners in identifying pedagogical strengths and weaknesses and connects theoretical knowledge to practical applications.
4. Self-Recording and Playback Opportunities: A critical interactive component is the opportunity for self-recording and playback. Many microteaching programs incorporate video recording of pre-service teachers' own teaching sessions, which they can later review independently or with supervisors and peers. This self-observation promotes metacognitive awareness, allowing teachers to identify areas needing improvement, recognize successful strategies, and set goals for future lessons (Loughran, 2010). The ability to control playback—pausing, rewinding, or slow-motion viewing—enhances detailed analysis and reflection beyond what is possible in live teaching observations.
5. Supplementary Instructional Materials: Pre-recorded video resources are often supplemented with additional instructional materials such as lesson plans, teaching guides, rubrics, and discussion questions. These supplementary materials provide context and structure to the video content, guiding pre-service teachers on what to focus on and how to apply observed strategies (Mayer, 2021). They also facilitate more structured reflection sessions and group discussions, bridging the gap between video observation and classroom application.
6. Technical Quality and Accessibility Features: To be effective, pre-recorded video resources must have high technical quality, including clear audio, good lighting, and stable visuals, ensuring that instructional content is easily observable and comprehensible (Ogunlade, 2022).

Additionally, accessibility features such as subtitles, transcripts, and language options enhance usability for diverse learners and support inclusive education practices. These features are especially important in resource-constrained settings where learners might have varying levels of digital literacy and access to technology.

Roles of Pre-recorded Videos in Enhancing Microteaching Competence

Pre-recorded video resources have become integral tools in teacher education, particularly for enhancing microteaching competence among pre-service teachers. Their multiple roles contribute to improving instructional skills, reflective practice, and professional growth. This section outlines the key functions and educational benefits of pre-recorded videos in the microteaching context.

1. Facilitating Repeated Observation and Self-Paced Learning: One of the primary roles of pre-recorded videos is enabling repeated viewing, allowing pre-service teachers to observe teaching demonstrations or their own lessons multiple times at their convenience. This flexibility supports self-paced learning, where learners can control the speed and frequency of engagement according to their individual needs (Mayer, 2021). Such repeated exposure aids in deeper comprehension of teaching techniques, classroom management strategies, and pedagogical nuances that may be missed during a single live observation.
2. Providing Access to Expert Models and Exemplary Teaching Practices: Pre-recorded videos offer access to expert teaching models, demonstrating effective instructional strategies and classroom interactions that may not be readily available in every teacher education setting. Watching experts perform microteaching sessions allows pre-service teachers to internalize professional standards and adopt best practices (Seidel et al., 2013). This role is particularly crucial in contexts like Nigeria, where direct observation of experienced teachers may be limited by resource constraints and large class sizes (Ogunlade, 2022).
3. Enhancing Reflective Practice and Critical Analysis: Videos serve as powerful tools for reflection by providing concrete evidence of teaching performance. When pre-service teachers watch recordings of their own or peers' microteaching sessions, they can engage in critical self-analysis, identify strengths and areas needing improvement, and develop metacognitive skills essential for professional growth (Sherin & van Es, 2009). This reflective process is more objective and comprehensive than relying solely on memory or immediate verbal feedback.
4. Supporting Feedback and Collaborative Learning: The use of pre-recorded videos facilitates richer feedback processes, both from instructors and peers. Recorded lessons can be reviewed asynchronously, allowing more detailed and thoughtful comments (Obielodan & Adebayo, 2023). Video-based peer review encourages collaborative learning, where pre-service teachers learn not only from their own videos but also from critiquing others' teaching practices, thus broadening their perspectives and pedagogical understanding.
5. Bridging Theory and Practice: Integrating theory with practical demonstration, pre-recorded videos help pre-service teachers bridge the gap between theoretical knowledge and classroom application. They illustrate how abstract pedagogical concepts are enacted in real teaching scenarios, making learning more concrete and applicable (Gambari et al., 2022). This role enhances the relevance and retention of teacher education content.
6. Promoting Confidence and Reducing Anxiety: Microteaching can be anxiety-provoking for pre-service teachers due to performance pressure and fear of peer judgment. Pre-recorded videos allow learners to practice and review their teaching in a less intimidating environment, which can help build confidence gradually (Lawal, Adebisi, & Kamal, 2024). Being able to revisit and improve recorded performances before live sessions reduces anxiety and fosters a growth mindset.

Implications for Stakeholders

The integration of pre-recorded video resources in microteaching presents significant implications for various stakeholders involved in teacher education. These stakeholders include curriculum designers, teacher educators, pre-service teachers, educational policymakers, and institutional administrators. Understanding these implications helps in leveraging the potential of video-enhanced microteaching to improve teacher preparation outcomes effectively.

Implications for Curriculum Designers

Curriculum designers are tasked with structuring teacher education programs that reflect current pedagogical innovations and meet the demands of modern classrooms. The adoption of pre-recorded video resources necessitates a review and redesign of existing microteaching curricula to incorporate blended learning approaches that combine face-to-face practice with digital video-based activities (Yusuf et al., 2021). This integration should ensure alignment between video content and learning outcomes, provide clear guidelines on video use, and include assessment criteria that recognize reflective video analysis as a core competency. Curriculum designers must also consider the inclusion of digital literacy components to prepare pre-service teachers for effective engagement with video tools.

Implications for Teacher Educators

Teacher educators play a pivotal role in facilitating microteaching and guiding reflective practice. The use of pre-recorded videos requires educators to develop competencies in digital content creation, video-based feedback provision, and moderation of video-enhanced peer discussions (Obielodan & Adebayo, 2023). Educators must also adopt new pedagogical roles as facilitators and mentors who support pre-service teachers in critically engaging with video materials. Furthermore, teacher educators should encourage a culture of reflective practice through structured video review sessions and support the development of pre-service teachers' self-evaluation skills.

Implications for Pre-service Teachers

For pre-service teachers, access to pre-recorded video resources enhances autonomy and flexibility in learning, allowing them to revisit teaching models and their own practice multiple times (Mayer, 2021). This fosters self-regulated learning, critical reflection, and continuous improvement. However, pre-service teachers must also develop skills in digital literacy and reflective analysis to maximize the benefits of video resources. The incorporation of video-enhanced microteaching requires learners to take active responsibility for their professional growth, engage constructively in peer feedback, and adapt to blended learning modalities.

Implications for Educational Policymakers

Policymakers at national and institutional levels have a responsibility to create enabling environments for the adoption of video-enhanced microteaching. This includes investing in digital infrastructure such as reliable internet connectivity, multimedia equipment, and video recording facilities in teacher training institutions (Ogunlade, 2022). Policies should also support professional development programs for teacher educators to build capacity in digital pedagogy. Additionally, policymakers must advocate for curriculum reforms that integrate technology-enhanced learning approaches and ensure funding mechanisms that sustain such innovations.

Implications for Institutional Administrators

Administrators of colleges of education and universities must prioritize resource allocation to support the acquisition and maintenance of video technologies and provide technical support for both educators and students (Wu, & Liu, 2021). Institutional leadership should foster partnerships with technology providers and encourage innovation in teaching practices. Administrators also need to establish protocols for video data management, privacy, and ethical use, ensuring that video recordings are used responsibly and securely.

Recommendations

1. Teacher education institutions should integrate pre-recorded video resources into microteaching programs to provide pre-service teachers with opportunities for repeated observation and self-paced learning.
2. Curriculum designers should revise microteaching curricula to include guidelines and assessment criteria that emphasize the use of video-based teaching and reflection.
3. Teacher educators should receive training on how to create, use, and provide feedback on video resources effectively to support pre-service teachers' learning.
4. Pre-service teachers should be encouraged to actively engage with video recordings, both of expert demonstrations and their own teaching, to improve reflective skills and instructional competence.
5. Educational policymakers and institutional administrators should invest in digital infrastructure such as reliable internet, video recording equipment, and technical support to facilitate the use of video resources.
6. Institutions should promote a culture of collaboration and peer feedback by organizing video-based discussion sessions where pre-service teachers can share insights and learn from one another.

Conclusion

Pre-recorded video resources play a vital role in improving microteaching competence among pre-service teachers by allowing them to observe expert teaching, reflect on their own practice, and learn at their own pace. When effectively integrated into teacher education programs, these videos help bridge the gap between theory and practice, enhance reflective skills, and build confidence. For maximum impact, there must be support from curriculum designers, educators, and policymakers to provide the necessary infrastructure and training. Overall, video-enhanced microteaching offers a promising approach to preparing skilled and reflective teachers for the future.

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STUDENT EXPERIENCE AND PERCEPTIONS OF COMPUTER-BASED TESTING IN HIGHER EDUCATION: EVIDENCE FROM OYO STATE INSTITUTIONS

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Abstract
This study examined student experience and perceptions of Computer-based Test (CBT) mode of examination in higher institutions of learning in Oyo State, Nigeria. The study adopted a descriptive survey research design with a sample of 200 undergraduate students selected across public and private institutions using stratified sampling techniques. Data was collected using a researcher-designed questionnaire titled Computer-Based Test mode of examination Questionnaire (CBTMEQ) and analyzed using frequency, percentage, and Relative Significance Index (RSI). The results revealed that students had positive experiences in computer-based test mode of examination, with 84.0% of students reporting positive experiences. The study also showed that students had a fairly effective to very effective experience with the use of Computer-based test mode of examination, with 49.5% describing it as fairly effective and 47.0% as very effective. The study concluded that students considered the use of Computer-Based Test mode of examination as effective and recommended the continuous use of Computer-Based Test mode of examination with adequate facilities.

Keywords: Computer-based testing, student experience, effectiveness, higher education, educational assessment

Introduction

During the past few years, technology has significantly reshaped the method of assessment. Technology has helped us in so many ways. Things that are difficult and no matter how we have to do it with our hands, technology has helped us to make it way easier for us by producing equipment and machines that help us to achieve it without stress. ICT may be the intelligence that helps. In education aspect, Information
Communication Technology has made education easier to achieve. One of the ways ICT has helped education is the use of computer-based testing (CBT). Computer-based testing might be a form of E-examination used to assess students or examiners. It is a more refined means of examination used in place of pen and paper. In essence, it is an assessment of students with the use of computers as an alternative method to pen and paper.

In CBT, computer technology is used in the administration of achievement or performance in form of test. Such assessments have been gradually supplanting paper-and-pencil tests in educational assessment since their introduction. A Computer Based Test System (CBTS) is a form of assessment in which the computer is an integral part of question papers' delivery, response storage, marking of responses or reporting of results from a test or exercise (Whillington 2000). It can be a multiple-choice question-based examination system that provides an easy-to-use environment for both Test Conductors and Students appearing for the Examination.

An effective method of student assessment is necessary as well as areas and levels of education. Due to an increase in student numbers, ever-escalating work commitments for academic staff and the advancement of internet technology, the use of computer-assisted assessment has been an attractive proposition for many higher institutions (Darrell, L.B.). In computer-based testing (CBT), computer technology is employed, which means the candidates use computers to answer questions presented on the monitor. The test-taker submits the answer using a keyboard or a mouse. Therefore, computer-based exams take place in a client-server environment. The attractiveness of CBT lies in its potential to expand, in multiple ways, the way educational assessment is conducted.

Since it was introduced to Nigeria, it was welcomed with mixed feelings as some said Nigeria is not developed enough to use it and others believed it was a step forward to a better form of examination. Though since its introduction, it has gone through many changes and development as it has greatly reduced malpractice and recording of missing candidates' answer sheets. Computer-based tests offer several benefits over traditional paper-and-pencil or paper-based tests. The Computer-based assessment provides opportunities to measure the complex form of knowledge and reasoning that is not possible to engage and assess through traditional methods. Consequently, in Nigeria, employers now conduct aptitude tests for job seekers through electronic means; the universities and other tertiary institutions are registering and conducting electronic examinations for their students through the internet and other electronic and networking gadgets. When it was introduced to higher institutions of learning in Oyo during the COVID-19 era, some students supported the idea while some students did not support it. Those who supported said it will help by not delaying the semester and those against it complained about not having a computer to do the examination and using a phone is not convenient. From the Oyo Higher Institution of learning students' perspectives of the CBT, there have been varying experiences and perceptions regarding its effectiveness and usability.

Statement of the Problem

The management of higher institutions in Oyo town implemented the use of Computer-based tests (CBT) for examinations to test students' knowledge during COVID-19 and since then continued using the CBT for undergraduate students. Though the advantages of using computer technology for educational assessment have been recognized which includes No impersonation, Time saving, Lower administrative cost. While recognizing these advantages, it is important to explore students' experiences and perceptions regarding the effectiveness of CBT systems. From the students perceptive judging from their experiences, there are varying views about computer-based test examination effectiveness and usability. In view of these varying perspectives, this study therefore seeks to undertake an assessment of students' experience and perception of Computer-based test examination effectiveness in Universities in Oyo State.

Objectives of the Study

The main objective of this study is to assess student experience and perceptions of Computer-based Test (CBT) mode of examination effectiveness in higher institutions of learning in Oyo State. The specific objectives are:

1. Examine the students' experience in Computer-based Test (CBT) mode of examination in Oyo State higher institution of learning.
2. Determine the effectiveness of Computer-based Test (CBT) mode of examination from students' perceptive in Oyo State higher institutions of learning.

Research Questions

The following research questions guided this study:

1. What are the students' experiences when using CBT?
2. How effective is CBT mode of examination from students' perspective in Universities in Oyo State?

Literature Review

Concept of Computer-Based Test

CBT may be defined as a way of using a computer to give exactly the same test as one in a paper-and-pencil format. It may also be described as computer-based testing as a method of administering tests in which the responses are electronically recorded, assessed or both. It often refers to assessments that are administered by computer in either standalone devices linked to the internet or world-wide-web (WWW), most of them using multiple choice questions. Sonali Rawat (2020) viewed Computer-Based Test as the dawn of online assessment in examination industry. He argued further that computer-based test (CBT) is a medium, or a technique to conduct an online Examination without pen & paper.

Bennett (2015) stated that computer-based test represents a modern way of answering an examination question, replacing the written pen and paper (PNP) format. He further explained that CBT is a combination of networks, hardware and software as well as means of communication, collaboration and engagement that enables the processing, management and exchange of data, information and

knowledge. It can be understood to be a complex of artificial techniques and knowledge for solving an instructor's problem involving marking pen and an examination (Bennett, 2015).

Conole & Warburton (2005) defined CBT as 'the use of computers for assessing students' learning'. It is required to think, reconsider, and modify or change the traditional test methods. Electronic assessment tools have reduced the load of teachers and facilitated exams execution purposefully because of the inclusion of ICTs in education.

Benefits of CBT over Pen and Paper

Kuzmina (2010) as cited by Abdul Ngafif (2017) pointed out benefits of using computer (web-based exam) as a tool to test. Those benefits are 1) reduced testing time, 2) increased test security, 3) provision of instant scoring (the test can be discussed while the whole thing is fresh in the subjects mind; in selection where the number of candidates again immediate results are valuable; where a huge number of subjects is tested this facility is not so important), 4) better use of professional time, 5) reduced time lag, 6) greater availability: individuals can be tested in a computer setting individually or in groups, usually in more user-friendly environments than the large classroom auditoriums where paper and pen tests have been administered traditionally. 7) greater accuracy:

computers can combine a variety of data according to specific rules; humans is less accurate and less consistent when they attempt to do this.

Walker et al. (2004), as cited by Olafare& Boor (2018) itemized benefits of CBT over traditional paper-and-pencil or paper-based tests as follows: (1) It enhances speed of delivery, administration and scoring efficiency, (2) improved test security, consistency and reliability, (3) faster response rate among others.

Similarly, Samson (2017) identify benefits of CBT over Pen and paper to includes: (1) Security, (2) Secure test environment, (3) Consistency, (4) Conveniency and efficiency, (5) Innovation, data management and analysis,

(6) submission, auto-marking and examination result report generation.

Students' Experience in Computer-based Test (CBT) Mode of Examination

Jimoh, Yussuff, Akanmu, &Enikuomehin (2013) conducted research on students' experience of CBT mode of examination. The study revealed that students should had positive experience as they prefer computer-based test system better in writing their examinations than paper -- based test. Fluck, Pullen and Haper (2009) revealed that computer-based tests are easy to use for students as the features of computer-based test make it go beyond conventional practices and features. Hooshang Khosnsima, Seyyed &Nathan conducted research on Computer-based (CBT) vs. Paper-based (PBT) testing: mode effect, relationship between computer familiarity, attitudes, aversion and mode preference with CBT test scores results showed that 61% of their respondents stated that they liked the CBT environment because they could read one question on each page, they should click to highlight the correct answer and they were able to see the time on the corner of the screen. Telia and Bashorun (2012) conducted research on students' experience in Computer-based Test (CBT) mode of examination. The results demonstrated that the University of Ilorin students, their respondents, have positive experience towards CBT as more than half of them indicated a preference for CBT over PPT.

Effectiveness of Computer-based Test (CBT) Mode of Examination

Olafare, Sabainan Christopher & Anne (2017) conducted research on students' perception of Computer-Based Test in Nigerian Universities and their result revealed that computer-based test mode of examination is effective because students perceived computer-based test as useful. Aojula, Barber, Cullen & Andrews (2006) also reported that CBT is effective as it increases students' computer knowledge. Similarly, Aldersoon (2000) reported that students perceived computer-based test to be effective because its useful for assessment. Jimoh, Yussuff, Akanmu, &Enikuomehin (2013) revealed that students found computer-based test system better in writing their exams than the paper pen testing.

Sanni and Mohammad (2015) conducted a study on the views of students on the use of computer-based test for the conduct of UTME. The study found that the introduction of CBT for UTME examination attracted most of the students' attention and therefore led to CBT preference over the conventional way of writing the examination. The study revealed further that CBT can reduce examination malpractices and enhance security as opposed to paper-and-pencil test.

Abdul Ngafif (2017) identified effectiveness of CBT over Paper and pen mode of examination by listed some basic problems associated with the use of the conventional testing system: (1) students tend to do cheating, (2) the sleepy supervisors, (3) the inconsistency of test time, and the risk of losing the answer sheet. To overcome those problems, the researcher applies a concept called web-based exam system, which uses three main tools to run the system. The result shown that online mode of examination (online testing system) can overcome the problems found in conventional testing system.

Methodology

The study adopted a descriptive survey research design. Survey design allows the researcher to obtain information from a representative sample of a particular population on phenomenon of interest to the researcher. Since the researcher has no intention to manipulate any variable in the study, this design is found appropriate for a study of this nature. The population for the study comprised all undergraduate students of higher institutions in Oyo State. The sample size for this study comprised 200 undergraduate students. A stratified sampling technique was used to select 200 students across public and private institutions in Oyo State. With fifty students each selected from Alayande College of Education, Oyo, Federal School of Surveying, Oyo, Ajayi Crowther University, Oyo, and Atiba University, Oyo respectively. The instrument used to collect data for this study is a questionnaire titled: CBT mode of examination. Questionnaire (CBTMEQ). This instrument was a researcher-designed instrument. The items on the instrument were developed after an extensive review of literature in the related studies. The CBTMEQ consisted of five sections. Section A addressed the personal data of the students such as the name of institution, ownership of institution, department, gender, age, and current level of education. Section B comprised twelve (12) items that students experience in the CBT mode of examination. These items took on a four-point Likert Scale response format of Strongly Agree (4), Agree (3), Disagree (2) and Strongly Disagree (1). Section C comprised nine (9) items on the effectiveness of CBT mode examination from students' perceptive. These items took on a four point Likert Scale response format of Strongly Agree (4), Agree (3), Disagree (2) and Strongly Disagree (1). In order to ensure the validity of the instrument, the drafted copies of the instruments was subjected to the scrutiny by the researcher's supervisor and other experts in the field of Guidance and Counseling, Test and Measurement and Computer. The observations, comments, suggestions and corrections from these experts were effected. To determine the reliability of the instrument, 40 copies of the instrument were administered on students outside the locale of this study. Their responses to the instrument were scored and data generated was subjected to a reliability test via, internal consistency approach based on Cronbach's Alpha. The Cronbach's Alpha reliability coefficient values for sections B and C respectively were .73 and .82. These reliability coefficients are found high enough for the instruments to be used for the study. The data collected from student's responses were analyzed using descriptive analysis of frequency, percentage, and Relative Significance Index (RSI) to analyze the research questions raised.

Results

Research Question 1: What is the students' experience in Computer-Based Test (CBT) mode of examination in Oyo State higher institutions of learning?

61.5% of students strongly disagreed that they had not heard about CBT before, indicating high awareness . 77.5% of students (30.0% strongly agreed + 47.5% agreed) were comfortable using computers to write examinations. 72.0% of students (22.0% strongly agreed + 50.0% agreed) felt the timing of CBT examination was not biased. 81.5% of students (25.5% strongly agreed + 56.0% agreed) indicated that CBT examination was undertaken in a conducive environment. 77.5% of students (22.5% strongly agreed + 55.0% agreed) believed that CBT examination ensures fairness and equity. To determine the overall experience of students, their responses to the 12 items were scored and cumulated. The minimum and maximum responses obtainable were 12 and 48. High scores on this scale represent positive experience and vice versa. All negatively worded items were reversed in scoring before cumulating the responses. Scores of 12 through 30 on this scale were adjudged as Negative experience while scores of 31 through 48 were adjudged as Positive experience.

Table 1: Students' Experience in Computer-Based Test (CBT) Mode of Examination in Oyo State Higher Institutions of Learning

Experience Score Range Frequency (f) Percentage (%)	
12-30	32
31-48	168

Negative 16.0, Positive 84.0, Total 200 100.0

Results show that out of the 200(100.0%) students that participated in this study, 32(16.0%) had a negative experience while 168(84.0%) had a positive experience. As shown in the result, the experience of the majority of students in the higher institution of learning in Oyo State in the use of CBT was positive.

Research Question 2: How effective is CBT mode of examination from the perspectives of students in higher institutions of learning in Oyo State?

Students' responses to 9 items designed to measure CBT effectiveness were subjected to a descriptive analysis of frequency and percentage. Key findings include: 89.5% of students (33.5% strongly agreed + 56.0% agreed) indicated that CBT has given them greater awareness of its use, 87.0% of students (33.0% strongly agreed + 54.0% agreed) believed that CBT has helped in the conduct of large number of students within a time frame. 80.0% of students (26.0% strongly agreed + 54.0% agreed) found the speed of using CBT for examination satisfactory 83.5% of students (35.5% strongly agreed + 48.0% agreed) agreed that CBT helps to reduce missing scripts. 74.5% of students (24.5% strongly agreed + 50.0% agreed) indicated that CBT makes examination easier for them.To determine the effectiveness of CBT, students' responses to the 9 items were scored and cumulated. The minimum and maximum responses obtainable were 9 and 36. High scores on this scale represent more effectiveness, and vice versa. Scores of 9 through 18 on this scale were adjudged as Not Effective, scores of 19 through 27 as Fairly Effective, while scores of 28 through 36 were adjudged as Very Effective.

Table 2: Students' Description of Effectiveness of Computer-Based Test (CBT) Mode of Examination in Oyo State Higher Institutions of Learning

Description of Effectiveness Score Range Frequency (f) Percentage (%)

9-18	7
19-27	99
28-36	94

Not Effective 3.5 Fairly Effective 49.5 Very Effective 47.0 Total 200 100.0

Results show that out of the 200(100.0%) students who participated in this study, 7(3.5%) described CBT as not effective, 99(49.5%) described it as fairly effective, while 94(47.0%) described it as very effective. As shown in the result, while 49.5% of the students described CBT mode of examination as fairly effective, 47.0% described it as very effective.

Discussion

The results of this study have shown that the majority of the students in higher institutions had positive experiences in the use of the Computer-Based Test Mode of Examination in higher institutions of learning in Oyo town. In arriving at this conclusion, the data obtained from students' experience in Computer-Based Test Mode of Examination was considered along with the students' scores on items measuring their experience in the computer-based test mode of examination, leading to the same conclusion that the majority of students have positive experience. This finding corroborates the outcome of Aojula, Barber, Cullen & Andrews (2006) that computer-based test mode of examination (CBT) has a positive experience for students as it increases their computer knowledge. Similarly, Jimoh, Yussuff, Akanmu, Enikuomehin & Salman (2013) reported that students found CBT as a positive experience as they prefer CBT in writing their examination than traditional paper and pen testing. The results revealed Computer-Based Test Mode of Examination had fairly effective to very effective experience on the student results. This study is consistent with an earlier study carried out by Fagbola(2013), which revealed that

CBT mode of examination has been very useful in evaluating large students in various institutions across the world. Similarly, other findings, such as Tella and Bashorun (2012), revealed that students consider CBT mode of examination over PPT. Also, Okocha, Toluwani and Owolabi (2017) revealed that students are more interested in using CBT for examinations and tests than PPT. The majority of the students strongly agreed that CBT prevents frequent occurrences of students missing exam scripts. Abubarkar and Adebayo (2014) and Adebayo and Abdulhamid (2014) reveal that it promotes exam security. This finding also agrees with the study of Nwoke (2017) and Bala (2018), which revealed that the culminating benefit of CBT lies in its ability to curtail examination malpractice.

Conclusion

Based on the findings of this study, it can be concluded that students had a positive experience in Computer-Based Test Mode of Examination. Computer-based test mode of examination has helped to reduce the experiences of missing scripts, examination malpractices and despicable experiences by the students. It has also enhanced students' performance and gives credibility to scores obtained in such exams because marking is more accurate, consistent, and does not suffer from human error. Students perceived CBT as fairly effective to very effective, indicating strong acceptance and positive perception of the technology-enhanced assessment method.

Recommendations

From the findings of this study, the following recommendations were made:

1. Higher institutions should continue the use of Computer-Based Test mode of examination given the positive student experience and perceived effectiveness.
2. Orientation and tutorials should be organized to familiarize students with the testing environment prior to the commencement of the examination. This will help reduce their nervousness and improve their experience.
3. Government policy on computer education at the primary and secondary school levels should be reinforced to make all students computer-literate, thereby enhancing their CBT experience.
4. Higher institutions of learning should improve the efficiency of computer-based test to increase its credibility in testing students and enhance positive student experience.
5. Institutions should invest in user-friendly CBT interfaces and ensure adequate training for both students and staff to maximize the effectiveness of the system.

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AWARENESS OF GAMIFICATION TEACHING STRATEGIES AMONG TEACHERS IN SECONDARY SCHOOLS IN ILORIN-SOUTH LGA, KWARA STATE

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Abstract

Gamified teaching is one of the innovative teaching strategies in the 21^{st} century. However, the teachers were not aware of utilizing gamified teaching strategy for teaching. Specifically, the study sought to (i)examine the level of awareness of gamification teaching strategies among teachers in secondary schools in Ilorin-South LGA Kwara State, and (ii) the difference in the level of awareness of gamified-teaching among teachers based on gender. The study adopted the descriptive survey method, and questionnaire was the instrument used for data collection. The sample of the study was selected using simple random sampling technique. A researcher-designed questionnaire tagged Questionnaire on Awareness of Gamified-Teaching Strategy was used for data collection. Hence, a total of two hundred secondary school teachers responded to the questionnaire. The analysis of the data collected was done using both descriptive and inferential statistics of percentage, mean ranking and t-test. The findings of the study were that: the level of awareness of gamification-teaching strategies is high among teachers in secondary schools in Ilorin-South LGA Kwara State and there is a significant difference in the awareness of gamified-teaching among teachers based on gender [(198)=1.96,.p(0.00) < 0.05]. The study concluded that the level of awareness of gamification-teaching strategies is high among teachers in secondary schools in Ilorin-South LGA Kwara State. The study recommended among others that the adoption of such teaching strategies should be promoted in secondary schools in Kwara State.

Introduction

The use of gamification in education has gained increasing attention in recent years as a way to enhance student engagement, motivation, and achievement. Gamified, which grammatically referred to Gamification, refers to the use of game design elements, mechanics, and principles in non-game contexts such as education. Studies have found that gamification can improve learning outcomes such as academic performance, knowledge retention, and transfer of learning (Hamari, Koivisto, &Sarsa, 2020; Kapp, 2016). Gamification is the process of using game elements in non-game contexts such as education, with the aim of increasing motivation, engagement, and learning outcomes. The use of gamification in education has been shown to improve student motivation, engagement, and learning outcomes (Dicheva 2015; Sailer2017). There have been studies that have shown that gamification in education can improve student learning outcomes, particularly in the areas of motivation, engagement, and knowledge retention. In a study conducted by Chen (2017), gamification was found to have a positive impact on students' motivation and learning outcomes in a Chinese language class. Similarly, Kapp (2015) argued that gamification can improve student engagement and motivation by providing students with a sense of accomplishment and reward making attempts. However, despite the potential benefits of gamification, there have been concerns raised regarding the potential drawbacks of gamification in education. For instance, some critics argue that gamification may lead to a focus on extrinsic rewards rather than intrinsic motivation (Ryan & Deci, 2020). Moreover, there is a concern that gamification may not be suitable for all types of learning contexts and may not be effective in promoting deeper learning outcomes (GeeSeene, 2016). Therefore, it is essential to investigate the extent to which teachers are aware of, and utilize Gamified-teaching strategies in secondary schools in Ilorin South LGA. This study aims to address this gap in the literature and provide insights into the factors that influence teachers' decision to use or not use gamification when teaching.

Statement of the Problem

The study focuses on the awareness and utilization of Gamified-teaching strategies by teachers in secondary schools in Ilorin South LGA. Despite the potential benefits of gamification, there is a need to investigate the extent to which teachers are aware of and utilize gamification teaching strategies in secondary schools in Ilorin South LGA Thus, the study aims to identify the level of awareness of gamification among teachers, the extent to which it is being used. This study is crucial to understanding the current state of gamification in education in Nigeria and identifying ways to promote its effective implementation in senior secondary schools.

Purpose of the Study

This study examined the awareness and utilization of Gamified- teaching strategies by teachers in secondary schools in Ilorin South LGA. This study specifically;

1. examined the level of awareness among teachers regarding gamified teaching strategies in secondary schools in Ilorin-South LGA.
2. investigated awareness among teachers regarding gamified teaching strtegies based on gender.

Research Questions

The following research questions will guide this study:

1. What is the level of awareness of gamification teaching strategies among teachers in secondary schools in Ilorin-South LGA?
2. What is the awareness of secondary school teachers regarding gamified strategies based on gender?

Research Hypothesis

Ho_1: There is no significant difference in the level of awareness of teachers in the use of Gamified teaching strategies based on gender

Literature Review

Awareness of gamified teaching among teachers in secondary school

Gamified teaching is an innovative teaching approach that leverages elements of game design, such as competition, challenges, rewards, and interactivity, to create a more engaging and immersive learning experience for students (Deterding 2021). By integrating these game-like features into lessons and activities, educators aim to capture students' attention, stimulate personal intrinsic motivation, and foster active participation in the learning process. In many secondary schools, there exists a noticeable gaps in the awareness of gamified teaching among teachers. Several factors contribute to this limited awareness. Factors such as traditional pedagogical training where the majority of teachers receive traditional pedagogical training that may not cover innovative teaching methods like gamification (Deterding 2021). Resource Constraints In some regions, access to the necessary technological resources, including devices and educational software, is limited, impeding the implementation of gamified teaching (Hamari 2016).

Awareness and adoption of gamified teaching can bring forth numerous benefits to secondary education. Gamified learning environments capture students' attention and motivation, making learners active participants in education. Research indicates that gamified teaching can lead to improved academic performance, knowledge retention, and the development of critical thinking and problem-solving skills (Hamari 2016). Gamification encourages the development of essential skills such as teamwork, creativity, decision-making, and adaptability, which are increasingly vital in the modern world. Gamified systems can adapt to individual learning styles and paces, providing a tailored educational experience. (Eket 2020). Promoting awareness and fostering the integration of gamified teaching into secondary education is of paramount importance. Gamification has the potential to rekindle students' enthusiasm for learning, transforming education into a more enjoyable and effective endeavor. Familiarity with technology and gamified learning experiences equips students with essential skills and prepares students for the demands of the digital age. Embracing innovative teaching methods like gamification positions educational institutions and students as competitive entities on the global stage. (Eket 2020).

Thus, Awareness of gamified teaching among secondary school teachers is currently limited but holds immense potential for revolutionizing the education landscape. Addressing the challenges, providing comprehensive training, and promoting a paradigm shift in pedagogical approaches can pave the way for the integration of gamified teaching into secondary education. Ultimately, this shift can lead to increased student engagement, improved learning outcomes, and better preparation of students for the dynamic challenges of the 21st century.

The application of gamified teaching in the educational landscape has gained recognition for its potential to enhance student engagement and learning outcomes. However, the extent to which teacher gender influences the adoption and implementation of gamified teaching strategies remains a topic of interest and research. Gamified teaching is an instructional approach that incorporates elements of games into the learning process. It leverages game mechanics such as competition, rewards, challenges, and interactivity to create an engaging and immersive learning experience (Deterding 2021). While the effectiveness of gamified teaching has been widely acknowledged, its implementation can vary based on several factors, including the gender of the teacher. Teacher gender can influence perceptions and comfort levels when it comes to adopting gamified teaching strategies. Some studies suggest that male teachers may be more inclined to experiment with technology-driven or game-based approaches, (Van Eck, 2016). Female teachers, on the other hand, might exhibit a preference for more traditional instructional methods due to perceived comfort and familiarity.

Teacher gender can also impact the selection of games or gamification tools used in the classroom. Female teachers may be more likely to incorporate educational games that align with nurturing and collaboration, while male teachers might opt for competitive or skill-based games (Lynch 2015). These differences may reflect gender-specific teaching styles and priorities. Teacher gender can influence the dynamics of student-teacher interactions within gamified teaching environments. Some studies suggest that students may perceive male teachers who implement gamified strategies as more technologically competent or innovative (Zhang 2019). This perception can affect students' engagement and motivation in the classroom. Gender stereotypes can play a role in the adoption of gamified teaching.

Teachers may encounter gender-based expectations from students and parents, potentially influencing teacher’s choices in instructional methods. Female teachers, for instance, might face expectations to create nurturing and inclusive learning environments, while male teachers could encounter pressure to incorporate competitive elements (Van Eck, 2016). To ensure equitable and effective implementation of gamified teaching, it is essential to address potential gender-related challenges, Herrick (2015), stated that providing gender-inclusive professional development opportunities that focus on gamified teaching can empower all educators, irrespective of gender, to integrate innovative strategies into the classrooms. Raising awareness about the potential influence of teacher gender on instructional choices can help educators recognize and address biases, fostering a more inclusive and diverse teaching environment. And ensuring that curricular materials and resources are designed to accommodate various teaching styles and preferences can mitigate gender-related disparities in gamified teaching.

Methodology

Research Design

This study employed descriptive research design of the survey type which aimed at investigate the awareness and utilization of gamified teaching by teachers in senior secondary school in Ilorin South LGA

Sample and Sampling Techniques

All secondary school teachers in Ilorin South LGA, made up the study's population. The target population for this study were 200 secondary school teachers in Ilorin South LGA, two public schools and five private schools were chosen due to time restrictions. The secondary school teachers who took part in the study were chosen through the use of random selection techniques. Stratified random sampling was used to select secondary school teachers that participated in the study for gender consideration.

Table 1: Percentage Distribution of Respondents Based on Gender

Gender	Frequency	Percentage
Male	106	53.0
Female	94	47.0
Total	**200**	**100**

Table 1 showed the demographic data of the respondents on the basis of gender. Thus, 106(53.0%) of the respondents were secondary school teachers, while 94(47.0%) of the respondents were female secondary school teachers. This indicates that male secondary school teachers participated more in the study than the female secondary school teacher counterparts in Ilorin south L.G.A. Kwara State.

Research Question: Level of awareness of gamification teaching strategies among teachers in secondary schools in Ilorin-South LGA Kwara State?

Table 2: Mean and Rank Order of level of awareness of gamified teaching strategy by secondary teachers in secondary schools in Ilorin South LGA Kwara State.

S/N	Items	Mean	Rank	Decision

1	I am open to trying new teaching strategies, such as gamification	3.36	1st	High
2	I believe gamification can enhance student engagement and motivation	3.12	2nd	High
3	I am comfortable with integrating technology into my teaching practices	3.08	3rd	High
4	I believe gamification can help address classroom management issues	2.91	4th	High
5	I am aware of the potential challenges and limitations of gamification in education	2.84	5th	High
6	I am familiar with the concept of gamified teaching	2.81	6th	High
7	I have access to technology and resources needed to implement gamification in the classroom.	2.39	7th	Low
8	I am convinced that Gamification is a worthwhile means of learning.	2.38	8th	Low
9	I have used gamification in my classroom before.	2.37	9th	Low
10	I have received training on how to implement gamification in the classroom.	2.35	10th	Low

Table 2 showed the level of awareness of gamification teaching strategies among teachers in secondary school Ilorin south local government area Kwara State. Specifically, the items which shows the level of awareness of gamification teaching strategies among teachers in secondary school Ilorin south local government area Kwara State are in this study are; been open to trying new teaching strategies, such as gamification, believing gamification can enhance student engagement and motivation, been comfortable with integrating technology into my teaching practices, also believing gamification can help address classroom management issues, been aware of the potential challenges and limitations of gamification in education and familiarity with the concept of gamified teaching. Given that the mean scores of all the items are ranging from 2.81 - 3.36 which is higher than the cut-off or average mean score of 2.5, which was adopted as the benchmark mean score, it could be therefore be concluded that all these items shows a achieve a high level of awareness of gamification teaching strategies among teachers in secondary schools in Ilorin-South LGA Kwara State. Therefore, the level of awareness of gamification-teaching strategies is high among teachers in secondary schools in Ilorin-South LGA Kwara State.

Hypothesis : Ho_1: There is no significant difference in the level of awareness of teachers in the use of gamified teaching strategy based on gender

Table 3: Mean, Standard Deviation and t-value in the level of awareness of teachers in the use of Gamified teaching based on gender.

Gender	No	Mean	SD	Df	Cal .t-value	Crit. t-value	P-value
Male	106	26.58	4.65	198	3.43	1.96	0.00
Female	94	28.76	4.27				

Table 3 showed the calculated t-value was 3.43 while the critical t-value is 1.96 (0.00 < 0.05 level of significance). Since the calculated t-value is more than the critical value, the null hypothesis was rejected. This means that there is a significant difference in the level of awareness of teachers in the use of gamified teaching based on gender.

Discussion

The answering of research question indicated that the level of awareness of gamification-teaching strategies is high among teachers in secondary schools in Ilorin-South LGA Kwara State is high. This finding could be attributed to the way secondary school teachers in Ilorin South Local Government Area have high access to online learning resources through the internet. And other ICT devices that make it possible for them to be highly aware of gamification teaching strategies. This finding is in line with that of Adomi and Kpangban (2010), who found that online resources had a significant influence on the academic performance of students. This finding supports the earlier finding of Chen (2017) who found out that teachers had a high level of awareness on the use of gamification teaching strategies in the field of education. The testing of hypothesis one showed that there is there is a significant difference in the utilization of gamified teaching among teachers based on gender. That is, male and female secondary school teachers differed in their level of awareness of gamified teaching in Ilorin South Local Government Area.

Conclusion

Based on the findings of the study, it could be concluded that the level of awareness of gamification-teaching strategies is high among teachers in secondary schools in Ilorin-South LGA Kwara State. The study also concluded that there is a significant difference in the level of awareness of teachers in the use of gamified teaching based on gender.

Based on the conclusions of the study, the following recommendations are offered:

1. Funds, power supply, ICT facilities, and trained teachers should be provided for the effective use of gamified teaching strategies among secondary school teachers in Ilorin South Local Government Area.
2. Future researchers should expand the sample and locale scope of the respondents to remedy the limitations of the present study.

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PERCEPTION OF LECTURERS IN INTEGRATING MOBILE DEVICES FOR TEACHING UNDERGRADUATES IN LAGOS STATE, NIGERIA

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Abstract
The rapid advancement of mobile technology has significantly influenced teaching and learning practices in higher education worldwide. In Nigeria, particularly in Lagos State, the use of mobile devices among students and lecturers is growing, yet their integration into formal teaching remains inconsistent. This study investigates the perception of lecturers on the integration of mobile devices for teaching undergraduates in tertiary institutions across Lagos State. The study adopts a descriptive survey design, with data collected from a stratified sample of lecturers across public and private universities using structured questionnaires. The analysis explores factors such as awareness, perceived usefulness, ease of use, institutional support, and potential challenges associated with mobile device integration. Findings reveal a generally positive perception among lecturers regarding the potential of mobile devices to enhance student engagement, access to learning materials, and flexibility in teaching. However, concerns were noted regarding digital distraction, lack of training, and inadequate institutional policies. The study recommends increased capacity-building initiatives for lecturers, provision of institutional frameworks for mobile learning, and development of policies that promote effective and secure mobile device usage in classrooms.

Keywords: Mobile learning, lecturer perception, higher education, mobile devices, Lagos State, teaching technology integration

Introduction

The integration of mobile devices into the teaching and learning process has become increasingly relevant in today's digital society. Mobile devices such as smartphones, tablets, and laptops offer new opportunities for flexible, personalized, and accessible education. In Lagos State, a hub of academic institutions in Nigeria, there is growing use of such technologies by students, but the extent to which lecturers perceive and integrate them in teaching remains under-researched.
Mobile technology has the potential to transform traditional teaching methods by encouraging interactivity, collaboration, and access to a vast range of resources. This study seeks to examine lecturers' perceptions towards integrating mobile devices in the classroom and the challenges and benefits that come with it.

Statement of the Problem

Despite the availability and proliferation of mobile devices in Nigerian universities, especially in Lagos State, many institutions still rely on conventional methods of teaching. There appears to be a gap in understanding the perceptions of lecturers, who are key stakeholders in determining how and when mobile technology is adopted in the teaching process. Without understanding their views, efforts to implement mobile learning strategies may be ineffective or resisted.

Purpose of the Study

1. To investigate lecturers' awareness and usage of mobile devices in teaching undergraduates.
2. To assess lecturers' perceptions of the usefulness and challenges of integrating mobile devices into teaching.
3. To explore institutional support available for lecturers using mobile devices.
4. To recommend strategies for effective integration of mobile devices in higher education.

Research Questions

1. What is the level of awareness and usage of mobile devices by lecturers for teaching in Lagos State?
2. What are lecturers' perceptions of the usefulness of mobile devices in enhancing undergraduate teaching?
3. What challenges do lecturers face in integrating mobile devices in teaching?
4. What support systems are available to lecturers for implementing mobile learning?

Literature Review

Mobile learning (m-learning) has been defined as the use of mobile or wireless devices for educational purposes. According to Ally (2009), mobile devices can foster an engaging and personalized learning experience. Several studies (e.g., Traxler, 2007; Kukulska-Hulme & Traxler, 2010) have shown that mobile technology promotes active learning, supports collaborative learning, and extends education beyond the classroom. In Nigeria, research by Adedoja et al. (2013) has highlighted both the potentials and limitations of mobile learning. While students are generally receptive to using mobile devices for academic purposes, many lecturers show hesitation due to limited training and lack of institutional incentives. The Technology Acceptance Model (TAM) by Davis (1989) is frequently used to study adoption, emphasizing perceived ease of use and perceived usefulness. This study is guided by the Technology Acceptance Model (TAM), which posits that user acceptance of technology is influenced by perceived usefulness and perceived ease of use. In this context, the model helps to explain how these perceptions shape lecturers' willingness to integrate mobile devices in their teaching.

Methodology

The study employed a descriptive survey design. The population consisted of lecturers from public and private universities in Lagos State. A stratified random sampling technique was used to ensure representation across institutions. A total of 120 lecturers participated.
Data was collected using a structured questionnaire comprising Likert-scale items on awareness, usage, perceived benefits, challenges, and institutional support. Descriptive statistics (frequency, percentage, mean) were used to analyze the data.

Results

1. Awareness and Usage: Most lecturers reported being aware of mobile teaching tools, but only about 40% actively used them in their classrooms. Use was more prevalent in private institutions.
2. Perceived Benefits: Respondents noted that mobile devices could improve student participation, provide easy access to materials, and support flexible learning. Some mentioned using mobile apps like WhatsApp, Google Classroom, and Zoom.
3. Challenges: Key concerns included lack of training, fear of distraction, unstable internet, and insufficient institutional support.

4. Institutional Support: While some universities provided Wi-Fi or digital literacy training, many respondents reported limited or no support.

These results align with earlier research suggesting that while mobile learning holds promise, its success depends largely on educator readiness and systemic support.

Conclusion

The study found that while lecturers in Lagos State generally have a positive perception of mobile device integration in teaching, there are practical challenges that hinder full adoption.

There is a need for professional development programs to enhance digital teaching skills. Institutions should establish clear policies and invest in infrastructure that supports mobile learning.

Recommendations

1. Organize regular digital literacy workshops for lecturers.
2. Provide stable internet and device access within campuses.
3. Develop institutional policies that encourage innovation in teaching.
4. Promote awareness of mobile learning benefits through faculty seminars.

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LEVEL OF AWARENESS AND USAGE OF EMERGING EDUCATIONAL TECHNOLOGY IN TEACHING AND LEARNING AMONG TEACHERS IN LAGOS EDUCATION DISTRICT VI

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Abstract
This study aims to assess the digital literacy of teachers in Lagos State, Nigeria, in relation to the implementation of new education technologies in instruction and learning. As fast paced as the development of digital technologies and platforms is, education has also been under the mandate of integrating technology. However, most teachers do not possess the capacity to efficiently deploy these technologies to instruction, based mainly on the fact that they have varying levels of digital literacy. The research examines teachers' attitude towards educational technologies, their application of such technologies, and the determinants of adoption, including teacher-related determinants (competence, motivation, and attitudes) and school-related determinants (infrastructure, access to training, and support). The research also examines potential strategies for enhancing teachers' expertise in the application of new educational technologies with the aim of increasing the quality of education. Using mixed-methods design, the research will collect data using surveys and interviews from educators in various schools within the Lagos State. The outcomes will further clarify the existing gaps in digital literacy and provide guidelines for the design of effective professional development programs that will help teachers effectively integrate educational technology. Lastly, this study aims to contribute to the design of a more technologically inclusive learning environment that fosters innovation and improves learning for Lagos State students and potentially other settings.
KEYWORDS: Digital literacy, educational technologies, Instruction and learning, Technology integration, Teacher-related determinants, School-related determinants,

Introduction

The 21st century has witnessed a paradigm shift in the way knowledge is delivered and acquired, owing largely to the emergence of technology in education (Obielodan & Akinsola, 2021). Educational technologies such as virtual learning environments, interactive whiteboards, online assessments, and digital collaboration tools have transformed the traditional classroom into a more dynamic and engaging learning space (Okonkwo & Udo, 2022). These tools have the potential to enhance instructional efficiency, cater to diverse learner needs, and promote learner autonomy (Afolabi & Eze, 2023).

In Lagos State, the government has made significant efforts to incorporate ICT into the education system through the provision of computer laboratories, training programs, and integration of digital literacy into the curriculum (Ogunyemi & Balogun, 2021). Education District VI, which includes schools in local government areas such as Mushin, Surulere, and Mainland, is no exception to this drive. However, the success of these initiatives depends largely on teachers' awareness, readiness, and willingness to adopt and use these technologies Alabi, T. A., Yusuf, M. A., & Bello, K. M. (2022).

While some teachers have embraced the shift, many others remain unaware or hesitant to incorporate these tools into their pedagogy (Ibrahim & Oladele, 2023). Understanding the level of awareness and actual usage of emerging educational technology among teachers is vital to informing policy and practice (Chukwuma & Odum, 2020). This study, therefore, seeks to explore how well teachers in District VI understand and utilize emerging EdTech tools and identify factors influencing their adoption.

Statement of the Problem

Despite considerable investment and effort in promoting educational technology, there remains a noticeable gap between awareness and practical implementation among teachers in Lagos State. In many cases, the digital infrastructure exists, but is underutilized. Teachers often lack adequate training or the confidence to implement these tools in the classroom. Consequently, the intended benefits of improved learning outcomes and interactive pedagogy remain unfulfilled.

In Education District VI, where public schools vary widely in resources and training access, these issues are more pronounced. Without concrete data on teachers' awareness and use of educational technology, education stakeholders are limited in developing effective interventions. This study addresses that gap by providing empirical evidence on the level of awareness and extent of usage of EdTech tools by teachers in the district.

Research Questions

1. What is the level of awareness of teachers in Lagos State regarding the use of emerging educational technology in teaching and learning?
2. To what extent do teachers use emerging educational technology in teaching and learning?

Literature Review

Teachers' Awareness Level on the Application of Emerging Educational Technology

Teachers' awareness of emerging educational technologies plays a crucial role in their ability to integrate them into instructional practices. In Lagos State, most teachers are familiar with basic tools such as Microsoft Office and Google Classroom but lack awareness of more advanced technologies like virtual reality (VR) and artificial intelligence (AI) (Olanrewaju, 2020). This limited awareness restricts their ability to explore diverse and innovative instructional methods. Mbah and Osabohien (2020) also noted that awareness gaps often stem from insufficient exposure to current trends in educational technology.

In addition, professional development opportunities aimed at improving teachers' technological competence are often short-term and inconsistent. Although government-led initiatives exist, they tend to lack continuity and depth, failing to provide sustained engagement with emerging tools (Adeosun & Olanrewaju, 2021). Without ongoing learning and training, teachers may become outdated in their practices, missing opportunities to enhance student learning through technology. Hence, continuous awareness and exposure are essential for effective technology integration in schools.

Extent of Adoption of New Teaching Technologies

While the presence of educational technology tools is increasing in Lagos State, their actual usage in classrooms remains limited. Olanrewaju and Mbah (2021) found that many teachers primarily use digital tools for administrative tasks like grading and attendance, rather than instructional delivery. This points to a discrepancy between technological availability and its pedagogical use, suggesting that training and hands-on familiarity may still be lacking among educators.

Moreover, infrastructure challenges significantly affect the level of technology adoption. Adeyemi and Akinola (2020) emphasized that poor internet connectivity and insufficient digital devices hinder the integration of technology in many schools. Teachers are also reluctant to explore unfamiliar tools due to limited technical support and confidence. As Hassan and Lodi (2020) argue, successful adoption of EdTech depends not only on availability but also on a supportive environment that encourages experimentation and sustained usage.

Methodology

The study adopted a descriptive survey design. The target population consisted of teachers in senior secondary schools across three local government areas within Education District VI. A sample representing 10% of the total teacher population in these areas was selected using stratified random sampling. Data was collected through a structured questionnaire focusing on awareness, usage, and influencing factors of EdTech adoption. Data was analyzed using descriptive statistics including frequency counts and percentages.

Result

The results of the data analyses for the study. The presentations were organized according to the research questions and null hypotheses that guided the study.

Research Question 1: What is the level of awareness of teachers regarding the use of emerging educational technology?

Table 1: Percentage Distribution of Teachers' Awareness of Emerging Educational Technologies

S/N	Item	Not Aware (%)	Minimally Aware (%)	Aware (%)	Highly Aware (%)
1	Augmented Reality (AR) Headsets	26.4%	23.3%	32.6%	17.8%
2	Virtual Reality (VR) Headsets	24.0%	21.7%	34.9%	19.4%
3	Interactive Whiteboards	12.4%	18.6%	38.0%	31.0%
4	3D Printers	27.1%	30.2%	25.6%	17.1%
5	Robotics Kits	33.3%	29.5%	24.0%	13.2%
6	Gamification Platforms	21.7%	28.7%	32.6%	17.1%
7	Learning Management Systems (LMS)	9.3%	12.4%	36.4%	41.9%
8	AI-based Tutoring Systems	18.6%	23.3%	38.8%	19.4%
9	Adaptive Learning Software	17.1%	26.4%	39.5%	17.1%
10	Cloud-based Collaboration Tools	12.4%	21.7%	36.4%	29.5%

Table 1 presents the level of awareness of teachers regarding various emerging educational technologies. The data reveal that teachers demonstrated the highest awareness of Learning Management Systems (LMS), with 36.4% aware and 41.9% highly aware, followed by Cloud-based Collaboration Tools (36.4% aware and 29.5% highly aware), and Interactive Whiteboards (38.0% aware and 31.0% highly aware). On the other hand, Robotics Kits and 3D Printers had the highest percentage of respondents who reported being not aware, with 33.3% and 27.1% respectively, suggesting limited exposure or training on these technologies.

The relatively high awareness of software-based tools like LMS and cloud-based platforms indicates a growing familiarity with digital platforms that are more accessible and commonly used in educational settings. However, the lower awareness levels for advanced or hardware-intensive technologies such as AR/VR headsets and robotics suggest a technological gap, likely driven by lack of training or resource availability. These findings highlight the need for targeted professional development initiatives that expand awareness and competence in underutilized but potentially impactful technologies.

Research Question 2: To what extent do teachers use emerging educational technologies in teaching and learning?

Table 2: Percentage Distribution of Utilization of Emerging Educational Technologies

S/N	Item	Rarely (%)	Sometimes (%)	Often (%)	Always (%)
1	Augmented Reality (AR) Headsets	40.3%	34.1%	17.1%	8.5%
2	Virtual Reality (VR) Headsets	37.2%	35.7%	17.8%	9.3%
3	Interactive Whiteboards	18.6%	29.5%	34.9%	17.1%
4	3D Printers	42.6%	30.2%	17.1%	10.1%
5	Robotics Kits	48.1%	29.5%	13.2%	9.3%
6	Gamification Platforms	26.4%	32.6%	28.7%	12.4%
7	Learning Management Systems (LMS)	14.0%	28.7%	32.6%	24.8%
8	AI-based Tutoring Systems	25.6%	34.9%	26.4%	13.2%
9	Adaptive Learning Software	22.5%	35.7%	28.7%	13.2%
10	Cloud-based Collaboration Tools	18.6%	31.8%	30.2%	19.4%

Table 2 illustrates the extent to which teachers utilize various emerging educational technologies in their teaching practices. The data show that Learning Management Systems (LMS) had the highest usage frequency, with 32.6% of respondents using it often and 24.8% using it always. This was followed by Cloud-based Collaboration Tools, where 30.2% reported using them often and 19.4% always. In contrast, technologies like Robotics Kits, 3D Printers, and AR/VR Headsets were reported as rarely used, with 48.1%, 42.6%, and 40.3% of teachers respectively indicating minimal use.

The trend reflects a greater integration of digital platforms that are easily accessible and relatively affordable, such as LMS and collaboration tools, while more advanced or infrastructure-dependent technologies remain underutilized. This disparity suggests that while digital adoption is advancing in some areas, it remains constrained by availability, cost, and training in others. These findings point to the need for strategic investment in training and resources, particularly for immersive and hardware-based tools, to ensure more balanced technology integration across classrooms.

These findings call for multi-stakeholder efforts training institutions, government bodies, and private sector actors to ensure a sustainable and inclusive framework for digital technology adoption in education.

Discussion

The findings of this study reveal an apparent difference between what teachers do know regarding newly emerging education technology and what they actually use in the classroom. While most teachers are aware of commonly available tools like Learning Management Systems (LMS) and collaboration tools, few know about or can use emerging technology like AR/VR, robotics kits, and AI tutorial systems. The key impediments to integration are lean infrastructure, poor provision of the internet, fear of technological breakdown, and lack of context-specific, practice-based training. Younger and recently trained teachers are more flexible, and hence peer mentorship and differentiated capacity development programs must be initiated. Encouragingly, an overwhelming majority of teachers indicated a willingness to integrate technology with adequate support, and this underscores the importance of specific professional development and ongoing investment in infrastructure.

Conclusion

Awareness alone is not enough to guarantee the success of EdTech deployment; teachers must be empowered by hands-on training, infrastructure facilities, and a supporting school environment. Educational technology integration implementation is multifaceted, encompassing more than devices and connectivity—quality teacher development and leadership. Although challenges persist, the positive attitude of teachers towards digital tools is a promising sign. By embracing a holistic and steadfast approach in training, resource provision, and leadership support, Lagos schools and by extension, Nigeria can facilitate innovative, forward-thinking learning and teaching environments.

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AN INVESTIGATION INTO SOFT SKILLS INTEGRATION IN TEACHER TRAINING PROGRAMME IN HIGHER INSTITUTIONS OF LEARNING IN LAGOS STATE - NIGERIA

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Abstract:
This study investigates how soft skills are integrated into teacher training programmes in higher institutions of learning in Lagos State, Nigeria. In today's changing education system, teachers need more than subject knowledge—they need strong communication, emotional intelligence, adaptability, and teamwork skills. However, teacher education in Nigeria has focused mainly on academic content and pedagogy, often overlooking the development of soft skills. Using the social constructivist theory by Vygotsky as the study's framework, this research explores how soft skills are currently included in the curriculum, how teacher educators and trainees view their importance, the challenges involved, and the strategies that can improve their integration. The study adopted descriptive survey design with stratified sampling technique and simple random sampling technique used to select a sample size of 1000 respondents. It utilized questionnaire to collect its data from both teacher educators and student-teachers. The quantitative data were analyzed using descriptive and inferential statistic. Data analysis shows that soft skills are only moderately included in training programmes, with limited practical exposure and weak assessment structures. Most student-teachers show better skills in communication and teamwork but struggle with emotional intelligence and critical thinking. The study also found that interpersonal and emotional skills are essential for managing diverse classrooms, especially in a multicultural and fast-paced setting like Lagos. Challenges include outdated curricula, lack of trained facilitators, overcrowded classrooms, and poor assessment models. Recommendations include revising the curriculum to include soft skills courses, training lecturers, adopting experiential learning methods, and partnering with schools for practical exposure. This study highlights the need for urgent reforms to make soft skills a core part of teacher education in Nigeria.

Keywords: Soft Skill, Teacher training Programme,

Introduction

In today's rapidly evolving global society, the demand for educators who not only possess strong academic knowledge but also exhibit well-rounded soft skills has increases significantly. Soft skills, which include communication, emotional, intelligence, problem -solving, adaptability, teamwork and leadership are essential in fostering effective teaching and learning experiences (Robles, 2012). As teaching extends beyond the delivery of content, the integration of these skills into teacher training programmes become imperative, particularly in a culturally diverse and complex context like Lagos state, Nigeria. The role of soft skills n education is gaining international attention with global educational policies emphasizing the importance of holistic teacher development (OECD, 2015).

In Nigeria, however, teacher education has traditionally prioritized content knowledge and pedagogy, often neglecting the intentional development of soft skills (Ajayi, 2019). This gap contributes to issues such as poor classroom management, weak student-teacher relationships and limited innovation in instructional delivery. Given the dynamic nature of today's classrooms and the unique challenges faced by teachers in urban environments like Lagos, a deliberate focus on soft skills training is necessary.

Lagos state, being Nigeria's commercial hub and a melting pot of diverse ethnicities, presents both opportunities and challenges for teachers. The diverse student population, coupled with the fast-paced nature of the city requires educators to be emotionally intelligent, culturally responsive and effective communicators (Adebayo &Amosun, 2020). Teacher training institutions in Lagos are therefore at the forefront of shaping the kind of educators the future demands. However, there is limited empirical data on how these institutions integrate soft skills in their programmes and whether these skills are assessed and developed alongside academic competencies (Okon & Bassey, 2021). Despite the rising recognition of the value of soft skills in teacher performance and student outcomes, the curriculum in many Nigerian teacher education institutions remain largely rigid and traditional (Ogunyemi, 2017). This is in contrast with trends in more advanced educational systems where soft skills are embedded within course objectives, student's assessment and practicum experiences (Trilling & Fadel, 2009). For instance, successful teacher training programmes in countries such as Finland and Singapore integrate reflection, communication and collaboration as core competencies (Darling-Hammond, 2017).

Moreover, employers in the education sector increasingly value graduates who demonstrate strong interpersonal and intrapersonal abilities. Yet, many newly qualified teachers in Nigeria report feeling ill-equipped to handle the social and emotional demands of the classroom (Umar & Yusuf, 2020). This highlights a significant gap between training and practice, necessitating a re-examination of curriculum design, teacher mentorship and institutional policy in higher education. This study, therefore, investigates the extent to which soft skills are integrated into teacher training programmes in higher institutions of learning in Lagos state. It explores the perception of teacher educators and trainees, identifying existing practices and examine the challenges and prospects of embedding soft skills into formal teacher education curricular. The findings will help the policy makers, curriculum developers and educational institutions towards enhancing teacher quality in Nigeria.

Statement of the Problem

Despite increasing global emphasis on holistic teacher preparation, the integration of soft skills into teacher training programmes in Nigeria remains insufficient and inconsistent. Research has shown that teacher education in many Nigerian higher institutions still places a disproportionate focus on content knowledge and theoretical pedagogy, often neglecting the development of essential non-cognitive skills such as emotional, intelligence, communication, adaptability and teamwork (Ajayi & Akindele, 2020; Adebayo et al, 2022). In Lagos state- a densely populated, culturally diverse urban center-the classroom environment presents unique challenges that demand a high level of social competence from teachers. However, many student-teachers report feeling unprepared to manage classroom diversity, resolve conflicts, or engages students effectively due to a lack of formal training in soft skills (Nwachukwu & Ayeni, 2022). While institutions recognize the importance of soft skills, there is a clear gap between policy intentions and actual practice. Educators often lack the tools and training necessary to teach or assess soft skills systematically (Ibrahim & Bello, 2023), and the absence of dedicated curriculum content further widens this gap. By these concerns, it becomes necessary to investigate how soft skills are currently integrated into teacher training programmes in Lagos state assess the challenges and propose strategies to enhance their inclusion in future curriculum reforms.

Purpose of the Study

The main objectives of this research is to investigate the integration of soft skills in teacher training programmes in higher institutions in Lagos state, Nigeria. The specific objectives are to:

1. Examine the extent to which soft skills are embedded in the teacher training curricular of higher institutions in Lagos state
2. Assess the perception of teacher educators and trainee teachers on the relevance of soft skills in teaching and learning.
3. Identify challenges facing the integration of soft skills in teacher education programmes
4. Propose strategies for improving soft skills training and assessment within teacher training institutions.

Research Questions

1. To what extent are soft skills integrated into the teacher training curricula in higher institutions in Lagos- state?
2. What are the perceptions of students-teachers and lecturers about the integration of soft skills into teacher training programme?
3. What are the major relevance of soft skills integration into teacher training programme during teaching training exercise?
4. What strategies can be adopted to improve the integration of soft skills into teacher training programmes in higher institutions?

Literature Review

Soft skills encompass a range of interpersonal, communication and emotional, intelligence competencies that support effective professional behaviour and personal interaction. These include skills such as teamwork, adaptability, leadership and empathy qualities considered indispensable for teachers (Bano et al, 2021). In teacher education, soft skills contribute significantly to creating inclusive and engaging classrooms (Hargreaves, 2020). According to Lucas and Claxton (2021), the future of education hinges on equipping teachers not only with cognitive skills but also emotional relational capacities.

Adejumo (2023) emphasized role in resolving classroom conflicts, managing diversity and fostering a supportive learning environment. In another hand, Aina and Oboh (2021) noted that emotional competence, empathy and classroom communication skills are key indicator of teacher effectiveness.

Across the global education system, countries like Finland and Singapore have embedded soft skills development into their teacher training scheme. According to Ng (2019), Singapore pre-service teachers undergo training in classroom empathy and peer collaboration. UNESCO (2021) advocated for future-ready teachers who are socially and emotionally competent to contribute to peaceful, inclusive societies. Trilling and Fadel (2019) also support that curriculum reforms is necessary to balance academic rigour with social competence in all educational system.

In African, precisely west Africa, the integration of soft skills is upcoming gradually. Adediran and Ojo (2020) conducted a study in southwestern Nigeria and found that while lecturers acknowledged the need for soft skills training but there must be standard framework for it. In Nigeria, the structure of teacher training curricular is largely influenced by national bodies like NCCE and NUC. These curricula are rich in pedagogy and subject content, they often lack depth in practical soft skills training (Adebayo et al, 2022). Oluwadare and Obielodan (2023) argue that many teachers enter the classroom academically prepared but socially unprepared. Findings from

Ajayi and Akindele (2020) showed that institutions emphasize cognitive development but do not little to nurture collaboration, critical thinking or resilience.

Adekoya and Usman (2024) reported that even when student-teachers engage in teaching practice, their reflection on social-emotional engagement is limited due to the absence of formal training in such areas. Moreso, Omodara and Lawal (2020) assert that institutions lack the infrastructure and instructional design to teach soft skills effectively. This leads to student-teachers relying on personal experience rather than structured learning. Okonkwo and Eze (2021) confirmed that although educators are aware of soft skills, most lack methodology to teach or assess them appropriately.

Educators and student-teachers in Lagos state have expressed mixed experiences regarding soft skills training. In a recent study of Nwachukwu and Ayeni (2022) found that most student-teachers only gain awareness of soft skills during teaching practice, not through classroom lectures. Ibrahim and Bello (2023) noted that soft skills are not clearly documented in course outlines and are rarely assessed in teacher education institutions. Some institutions on the other hand are making efforts. Oduoye and Akanji (2023) identified institutions piloting reflective journals and classroom discussion forums that promote empathy and interpersonal communication. These practices are isolated and not mainstreamed across all teacher education programmes. Ehiemua et al. (2024) emphasized the power of experiential learning-group projects, microteaching and service learning – as tools for fostering teamwork and emotional maturity. These approaches are yet to be adopted widely in Nigeria due to curriculum rigidity. Integration of soft skills has some challenges accompany it in Nigeria setting which include:

- Rigid curriculum- cuuricula focus on theoretical instruction (Omotayo &Uche, 2019).
- Overcrowded classrooms which hinder personalized learning and mentorship (Ogunyemi, 2020).
- Lack of trained facilitators who understand soft skills pedagogy (Bamidele et. Al., 2021).
- Absence of proper assessment models for evaluating soft skills (Ibrahim & Bello,2023).
- Institutional resistance to reform particularly where outcomes are measured only by cognitive performance (Adediran & Ojo, 2022).

Teachers are also burdened with large class sizes, making the implementation of reflective or student-centered methods difficult. Lawani and Okechukwu (2023) suggested that without enabling environments, any attempt at reform will struggle to take root. There are strategies for effective, integration and the following can be used to address these gaps. Ajayi and Akindele (2020) stated that curriculum review should be done which will include courses like emotional intelligence, professional ethics and interpersonal communication. There should be faculty development programmes to equip teacher educator with the capacity to model and teach soft skills according to Oduoye and Akaji (2023). Use of digital platforms and role-play to stimulate real-life teaching situations by Adekoye and Usman, (2024).

According to UNESCO (2021), there is need for partnerships with NGOs and international bodies for technical support and training resources. Trilling and Fadel (2019), asserted that a future-focused education system must teach “how to learn” alongside “what to learn”. Nigerian teacher education must follow suit by making soft skills development a core part of its educational philosophy.

Theoretical framework

Social constructivist theory by Lev Vygotsky (1978) guided this study. The theory emphasizes that learning occurs through social interaction and that individuals construct knowledge collaboratively within a cultural context. Vygotsky posited that communication, collaboration and social engagement are critical to cognitive development- skills that align directly with soft skills such as teamwork, empathy and communication. The relevance of this theory to integrating soft skills in teacher training as it highlights the importance of social interactions trainee must be equipped with these interpersonal skills to foster meaningful relationships and effective classroom practices, especially in diverse educational settings like Lagos state.

Methodology

This study adopted a descriptive survey research design, which was deemed appropriate because the study sought to gather data from a sample of respondents to describe the current status of soft skills integration in teacher training programmes in Colleges of Education in Lagos State. The descriptive survey design also allowed the researcher to examine the perceptions of both lecturers and pre-service teachers as well as institutional practices without manipulating any variables.
The population comprises teacher educators and student-teachers from all the higher institutions offering educational programme in Lagos state. (Colleges of Education and Universities). At the time of the study, Lagos State had ten recognized public and private tertiary institutions offering the Education courses, with an estimated population of 1500 lecturers and 24,000student teachers. A sample of 3500 respondents was selected for the study, consisting of 500 lecturers and 3000 student teachers drawn from the population of the study. The selection of these higher institutions was based on accessibility. Stratified random sampling was used to ensure proportional representation of both lecturers and student teachers across different departments and subject specializations. The main instrument for data collection was a researcher-designed structured questionnaire titled Soft Skills Integration Questionnaire (SSIQ). The instrument was divided into three sections: Section A collected demographic data of respondents; Section B teachers questionnaire; Section C questionnaire for student-teachers. The items were designed on a four-point Likert scale ranging from “Strongly Agree” to “Strongly Disagree.”

To ensure validity, the draft questionnaire was subjected to face and content validation by three experts in educational measurement and teacher education, who reviewed the items for clarity, relevance, and coverage of the study objectives. Based on their suggestions, minor revisions were made to improve the wording and remove ambiguities. The reliability of the instrument was determined using Cronbach’s alpha after administering the questionnaire to 20 respondents outside the study sample. The reliability coefficient obtained was 0.82, indicating a high level of internal consistency and reliability. The questionnaires were administered personally by the researcher and trained research assistants, who explained the purpose of the study and assured respondents of the confidentiality and anonymity of their responses. Out of 150 questionnaires distributed, 142 were properly completed and returned, yielding a response rate of approximately 95%, which was considered adequate for analysis. Data collected were analyzed using both descriptive and inferential statistical techniques. Frequencies, percentages, means, and standard deviations were used to summarize respondents’ demographic data and answer the research questions. Inferential statistics, particularly Pearson’s Product Moment Correlation and multiple regression analysis, were employed to test the null hypotheses at a 0.05 level of significance. All analyses were performed using the Statistical Package for Social Sciences (SPSS) version 25. The study adhered to all ethical standards of research, including obtaining informed consent from all participants, ensuring their voluntary participation, and guaranteeing confidentiality of data collected. Institutional approval was also sought from the management of each participating College before the commencement of data collection.

Results

Research Question One to what extent are soft skills integrated into the teacher training curricula in higher institutions in Lagos- state?

S/N	ITEM STATEMENT	SA	A	D	SD	MEAN	REMARK
1	Soft skills such as communication, teamwork and emotional intelligence are essential for effective teaching.	275 (55%)	150 (30%)	50 (10%)	25 (5%)	3.35	High agreement
2	The current teacher training curriculum in my institution adequately covers soft skills development.	250 (50%)	175 (35%)	50 (10%)	25 (5%)	3.30	High agreement
3	I have received formal training on how to teach or assess soft skills.	300 (60%)	125 (25%)	50 (10%)	25 (5%)	3.40	Strong agreement
4	Soft skills are clearly stated as learning outcomes in my course content.	288 (57.5%)	137 (27.5%)	50 (10%)	25 (5%)	3.37	High agreement
5	I integrate soft skills into my teaching methods (as through group work, role play or reflection).	263 (52.5%)	162 (32.5%)	50 (10%)	25 (5%)	3.33	High agreement
	Weighted mean					3.40	

Table 1 shows that the results indicate that a majority of respondents believe that soft skills are integrated into the teacher training curricula in higher institutions in Lagos- state. Over 85% of respondents either agreed or strongly agreed that the current teacher training curriculum in their institution adequately covers soft skills development, and they integrate soft skills into their teaching methods (as through group work, role play or reflection)

Research question two: What are the perceptions of student-teachers and lecturers about the importance of soft skills in teacher training?

Table 4.2: perceptions of students-teachers and lecturers about the importance of soft skills in teacher training

S/N	Statements	SA	A	D	SD	Mean	Remark
1	My institution provides workshops or seminars focused on soft skills for teacher trainers.	110 22%	100 20%	190 38%	100 20%	2.44	Low agreement
2	Assessment of soft skills is included in our student evaluation process.	201 40%	98 20%	168 37%	33 6%	2.93	High agreement
3	Lack of time and resources hinder the integration of soft skills into the curriculum.	250 50%	165 33%	75 15%	10 2%	3.31	High agreement
4	I believe soft skills should be taught as a separate course in teacher training programme.	269 54%	113 23%	85 17%	33 6%	3.23	High agreement
5	There is a need for curriculum reform to improve soft skills training in teacher education.	196 39%	185 37%	101 20%	18 4%	3.12	High agreement
	Weighted mean					3.2	

This analysis examines the perceptions of students-teachers and their lecturers about the importance of soft skills in teacher training. The mean scores indicate a high consensus on these perceptions

Research question three: What is the major relevance of soft skills integration into teacher training programme during teaching training exercise?

Table 4.3: relevance of soft skills integration into teacher training programme during teaching training exercise

S/N	Statements	SA	A	D	SD	Mean	Remark
1	I understand what soft skills are and how they apply to the teaching profession.	215 43%	119 24%	141 28%	25 5%	3.05	High agreement
2	My training programme has helped me improve my communication and interpersonal skills.	154 31%	104 21%	201 40%	41 8%	2.74	High agreement
3	Courses offered in my programme specifically focus on soft skills development.	136 27%	137 27%	188 38%	39 8%	2.37	Low agreement
4	Teaching practice (TP) helped me recognize the importance of soft skills in real classrooms.	258 52%	141 28%	73 15%	28 5%	3.40	High agreement
5	My lecturers frequently discuss the relevant of teamwork, empathy and adaptability in class.	267 53%	128 26%	99 20%	6 1%	3.31	High agreement
	Weighted Average					2.97	

The analysis shows major relevance of soft skills integration into teacher training programme during teaching training exercise. The high agreement of the mean scores indicate that the major relevance of soft skills integration into teacher training programme during teaching training exercise is the improvement in communication skill and interpersonal skill.

Research question four: What strategies can be adopted to improve the integration of soft skills into teacher training programmes in higher institutions?

Table 4.4: strategies can be adopted to improve the integration of soft skills into teacher training programmes in higher institutions

S/N	Statements	SA	A	D	SD	Mean	Remark
1	I feel confident in managing classroom challenges using soft skills.	273 55%	96 19%	101 20%	30 6%	3.22	High agreement
2	Soft skills were included in the feedback I received during my teaching practice.	199 40%	165 33%	96 19%	40 8%	3.05	High agreement
3	I think more attention should be given to soft skills in the teacher training curriculum.	176 35%	194 39%	91 18%	39 8%	3.01	Strong agreement
4	I learn most soft skills informally not through structured lessons or assessments.	241 48%	161 32%	82 17%	16 3%	3.23	High agreement
5	I believe soft skills should be taught as part of every education course not separately.	149 30%	210 42%	96 19%	45 9%	2.93	High agreement
	Weighted Average					3.09	

The findings demonstrate that strategies can be adopted to improve the integration of soft skills into teacher training programmes in higher institutions. One of such strategies is that soft skill should be taught as part of every education course. Also attention should be given to soft skills in the teacher training curriculum.

Discussion

Research question one stated that to what extent soft skills are integrated into the teacher training curricula in higher institutions in Lagos- state. The findings of this study reveal that soft skills are only moderately integrated into the curriculum and instructional practices of higher institutions in Lagos State. The finding is supported by the observation of Eze (2020) who stated that teacher education in Nigeria remains heavily focused on academic knowledge, leaving soft skills underemphasized. Although lecturers acknowledged the importance of soft skills, many lacked clear guidance on how to embed them in their teaching, consistent with the findings of Okafor and Nwankwo (2022), which highlighted the lack of lecturer preparedness as a barrier to effective integration. Research question two stated that: What are the perceptions of students-teachers and lecturers about the integration of soft skills into teacher training programme. The results showed that lectures and students-teachers perception about the importance of soft skill is above average. It finding showed that students-teachers demonstrated relatively higher competence in communication and teamwork compared to emotional intelligence and critical thinking. Nwachukwu and Ayeni (2022) supported the finding by stating that most student-teachers only gain awareness of soft skills during teaching practice, not through classroom lectures. Ibrahim and Bello (2023) also noted that soft skills are not clearly documented in course outlines and are rarely assessed in teacher education institutions. Some institutions on the other hand are making efforts.

Oduoye and Akanji (2023) identified institutions piloting reflective journals and classroom discussion forums that promote empathy and interpersonal communication.

On research question three which stated that: what is the major relevance of soft skills integratio n into teacher training programme during teaching training exercise. The analysis of the responses based on the research question revealed that interpersonal skills, communication skills, emotional skills are the significance of the integration of soft skills into teachers training programme. This is supported by Osagie and Onuoha's (2020) who opined that while Nigerian higher institution Lecturers often develop basic interpersonal skills through experience, deeper reflective skills like critical thinking are seldom cultivated during lecture courses. The positive and significant integration of soft skill into teacher training programme underscores the argument by Wats and Wats (2009) that systematic curriculum design is essential to developing these competencies rather than leaving them to chance. For research question four, the analysis discovered that there are several strategies that can be used to improve the integration of soft skills into teacher training programmes in higher institutions. These strategies include curriculum redesign to include soft skills components, capacity building for lecturers to teach soft skills effectively, collaboration with schools to align training with workplace demands, and the use of experiential learning methods such as role plays, group projects, and peer assessments.

Supporting this finding, Okoro and Udoh (2020) emphasize that embedding soft skills into the curriculum in a structured way ensures that they are taught deliberately and assessed appropriately, rather than being left to chance. Similarly, Adebayo (2019) argues that training and retraining of teacher educators is key to equipping them with the right tools and understanding to teach soft skills, especially in areas like communication, teamwork, and critical thinking. In agreement, Chikwe and Nwachukwu (2021) note that partnering with schools during teaching practice helps higher institutions tailor their training towards the actual needs of the job market, making soft skills training more relevant and practical.
However, some scholars question the practical impact of these strategies. For instance, Eze and Ojo (2020) argue that curriculum reforms often face resistance due to rigid institutional policies and the slow pace of change in public higher institutions. They believe that without systemic reform and policy enforcement, the suggested strategies may not lead to meaningful outcomes. Also, Musa (2022) criticizes the focus on experiential methods, pointing out that large class sizes and lack of resources in many Nigerian higher institutions make it difficult to implement hands-on approaches consistently.

Conclusion

This study looked into how soft skills are integrated into teacher training programmes in higher institutions in Lagos State, Nigeria. The findings show that while soft skills are present in the curriculum and teaching methods, the level of integration is only moderate. Both lecturers and student-teachers see soft skills as important, especially in areas like communication and teamwork. However, the study also found that skills such as emotional intelligence and critical thinking are not as strongly developed among student-teachers. It was clear from the responses that interpersonal, communication, and emotional skills are seen as valuable for integration into effective teacher training programme. The research also identified challenges such as limited curriculum content, lack of proper training for lecturers, and few opportunities for practical soft skills development. Despite these issues, the study outlined several useful strategies to improve soft skills training. These include redesigning the curriculum to give more space to soft skills, training lecturers to handle soft skills instruction, working closely with schools to connect theory with practice, and using active learning methods that help student-teachers develop and apply soft skills. Overall, the integration of soft skills into teacher education in Lagos State is moving in the right direction but still needs significant improvement. Strengthening these areas will better prepare future teachers to meet the demands of modern classrooms and contribute more effectively to the education system

Recommendations

1. Higher institutions should fully incorporate soft skills such as communication, emotional intelligence, critical thinking, and teamwork into their curriculum, ensuring they are taught and assessed deliberately across all levels of training.
2. Teacher educators should focus on soft skills instruction methods, so they are well-equipped to model and teach these skills to student-teachers.
3. Instruction strategies such as group projects, classroom simulations, peer reviews, and school-based teaching practice should center on soft skills application to bridge the gap between theory and real classroom demands.
4. Soft skills integration into teacher training programme should be aligned with what is needed in actual teaching environments, making the training more relevant and practical.
5. Government should provide institutional support and policy backing for soft skills integration, including funding, clear guidelines, and monitoring systems to ensure consistent implementation across departments and faculties.

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ASSESSING THE INTEGRATION OF EDTECHPRENEURIAL-PEDAGOGIES IN BUSINESS EDUCATION FOR STUDENTS' SELF-EMPLOYMENT READINESS IN UNIVERSITIES IN LAGOS STATE

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Abstract

This study assessed the integration of EdTechpreneurial pedagogies in Business Education for students' self-employment readiness in universities in Lagos State. Guided by Kolb's Experiential Learning Theory, the research examined students' exposure to entrepreneurial technology-based teaching, the types of EdTech tools used by lecturers, the perceived impact on self-employment readiness, and the challenges faced in the process. A census sampling technique was employed to study all 187 final-year Business Education students from the University of Lagos and Lagos State University. Data were collected using the "Students' Assessment of EdTechpreneurial Pedagogies in Business Education Questionnaire" (SAEPEBEQ), validated and tested for reliability (Cronbach's Alpha = 0.720–0.744). Descriptive statistics addressed the research questions, while Pearson correlation tested the null hypothesis at a 0.05 significance level. Findings revealed high student exposure to EdTechpreneurial pedagogies in theory; however, lecturers primarily used general productivity tools rather than market-relevant entrepreneurial platforms such as e-commerce builders, digital marketing tools, or business simulation software. Students reported low perceived preparedness for self-employment, and correlation analysis showed no statistically significant relationship between exposure and readiness ($r = 0.249$, $p = .056$). Major challenges included poor internet connectivity, inadequate institutional resources, and limited lecturer competence in identifying and applying entrepreneurial digital tools. The study concludes that EdTechpreneurial pedagogies in Business Education are present in appearance but lack the depth and practical engagement necessary for transformative impact. It recommends improving institutional infrastructure and implementing targeted lecturer training to identify, adopt, and effectively integrate market-relevant EdTechpreneurial tools into teaching, thereby enhancing students' readiness for entrepreneurship in a digital economy.

Keywords: *Edtechpreneurial Pedagogies, Entrepreneurial Readiness, Digital Tools, Self-Employment Preparedness.*

Introduction

The increasing complexity of the global economy, driven by digital disruption and innovation, has placed a new demand on higher education systems to produce graduates who are not only knowledgeable but also entrepreneurial and technologically competent. In Nigeria, this transformation is especially critical within the domain of Business Education, a field that serves as a bridge between theoretical knowledge and the practical competencies required for workplace and business success. Particularly, at the university level, Business Education is designed not only to provide learners with a comprehensive understanding of entrepreneurial practices, business planning, and digital tool application, but also to equip them with the pedagogical skills necessary to teach business-related subjects effectively (NBTE, 2022; Nwazor & Onokpaunu, 2016).

Hence, this dual objective, preparing both future business professionals and educators, makes the field uniquely positioned to contribute to national development through curriculum delivery, skills empowerment, and educational transformation. As such, innovations in Business Education pedagogy must consider not only content mastery but also the ability of graduates to design and deliver entrepreneurship and technology-integrated lessons to others in secondary schools, technical colleges, or training centres (Nebolisa, 2024). Therefore, embedding EdTechpreneurial pedagogies becomes not just a workforce readiness issue, but also a teacher preparation imperative. However, as the Fourth Industrial Revolution reshapes workforce expectations, questions have emerged about how effectively current pedagogical practices integrate digital entrepreneurship, especially in a country like Nigeria, where unemployment among graduates remains a national concern (Orji, 2024). This has given rise to scholarly discussions on integrating what can be termed EdTechpreneurial pedagogies, teaching strategies that combine the use of educational technology with entrepreneurial thinking to help students not only learn but also create business ventures using digital tools.

The newly released Core Curriculum and Minimum Academic Standards (CCMAS) for Education by the National Universities Commission (NUC, 2023) introduces important shifts that prioritise employability, innovation, and ICT competence. For Business Education, the curriculum includes courses such as “Digital Literacy,” “E-Commerce,” “Innovation and Creativity in Business,” and “Entrepreneurship and New Venture Creation,” among others. These courses indicate a clear intention to foster entrepreneurial thinking through digital learning frameworks. However, while the CCMAS provides structural opportunities, the effectiveness of this curriculum still heavily relies on how lecturers design, deliver, and engage students using appropriate pedagogies. According to Olatunji and Ajero (2022) and Udofia, Ijeoma and Chukwuemeka-Nworu (2021) argue, the success of any curriculum is determined not just by its content but by the strategies employed in its implementation. This creates a critical gap: are university lecturers in Business Education actually using EdTechpreneurial tools and methods to foster skills that can lead students to launch or conceptualise real business ventures? Or are digital tools still being limited to basic delivery methods such as PowerPoint, Zoom, or Google Meet, tools that do not necessarily lead to entrepreneurial outcomes?

This concern is particularly relevant to the University of Lagos and Lagos State University, where the Entrepreneurship and Skills Development Centre (ESDC) and Directorate of Skills Development & Entrepreneurship (LASUDSDE) exist, respectively, as institutional hubs for integrating skill development, digital innovation, and business creation across disciplines. While the centre’s existence aligns with national efforts such as the TETFund’s push for skills acquisition in tertiary institutions, it is unclear to what extent lecturers teaching Business Education draw from the institutional hubs’ resources or pedagogical models. According to Fayomi, Fields, Arogundade, Ojugbele, Ogundipe and Ganiyu (2019), many lecturers in Nigerian universities continue to approach entrepreneurship education from a theoretical lens, often neglecting the use of practice-based, tech-enabled learning strategies. This undermines the very goals of the curriculum, especially given that tools like Canva, WordPress, Google Workspace, Facebook, Instagram and WhatsApp Business, among many others, are freely accessible and capable of enabling students to experiment with business models in real time. Hence, it becomes necessary to investigate whether students in Lagos State Universities, studying the Business Education programme, are being exposed to such transformative teaching methods.

Statement of the Problem

The recent 2023 Core Curriculum and Minimum Academic Standards (CCMAS) in Business Education marks a significant departure from the narrow focus of the earlier Benchmark Minimum Academic Standards (BMAS, 2014), which largely emphasised preparing students as future business teachers. The revised curriculum now establishes a dual mandate: to equip students with pedagogical competencies for teaching business subjects and to prepare them for self-reliance through entrepreneurial venture creation. Central to this reform is the integration of technological innovation into the Business Education programme, thereby aligning it with national goals for digital transformation and youth empowerment. However, as ambitious as this curriculum shift may be, its success depends heavily on how well lecturers translate its intentions into classroom practice.

A key concern is that curriculum effectiveness is often constrained by the quality of its implementation. If lecturers continue to rely on conventional teaching approaches or limit their use of technology to content delivery alone, the transformative goals of the CCMAS may not be realised. Hence, the problem of this study is to investigate whether EdTechpreneurial tools that can empower students to build and apply business knowledge through technology are being actively deployed in classrooms. This is because without such assessment, the curriculum's promise to produce both competent teachers and innovation-driven entrepreneurs risks remaining on paper rather than manifesting in practice.

Purpose of the Study

The major aim of this study is to assess the integration of EdTechpreneurial Pedagogies in Business Education for Self-Employment readiness of the students in universities in Lagos State. Specifically, this study is guided by three objectives, which are to:

1. determine the level of students' exposure to EdTechpreneurial pedagogies in Business Education courses.
2. identify the types of EdTech tools and platforms lecturers use in the delivery of Business Education content.
3. evaluate the perceived impact of EdTechpreneurial pedagogies on students' preparedness for self-employment.
4. identify the challenges students face in benefiting from the integration of EdTechpreneurial pedagogies in Business Education

Research Questions

Four questions were answered in this study as follows:

1. What is the level of students' exposure to EdTechpreneurial pedagogies in Business Education courses.
2. What types of EdTech tools and platforms are lecturers using in the delivery of Business Education content?
3. What is the perceived impact of EdTechpreneurial pedagogies on students' preparedness for self-employment?
4. What challenges do students face in benefiting from the integration of EdTechpreneurial pedagogies in Business Education**?**

Research Hypotheses

One null hypothesis was tested in this study:

Ho_1: There is no statistically significant relationship between students' exposure to EdTechpreneurial pedagogies and their perceived preparedness for self-employment.

Theoretical Framework: Kolb's Experiential Learning Theory

The current study is grounded in David Kolb's Experiential Learning Theory (ELT), a dynamic model that explains how learners acquire and apply knowledge through experience. Kolb (1984), drawing from Dewey, Piaget, and Lewin, proposed that effective learning is a cyclical process involving four stages: Concrete Experience, Reflective Observation, Abstract Conceptualisation, and Active Experimentation.

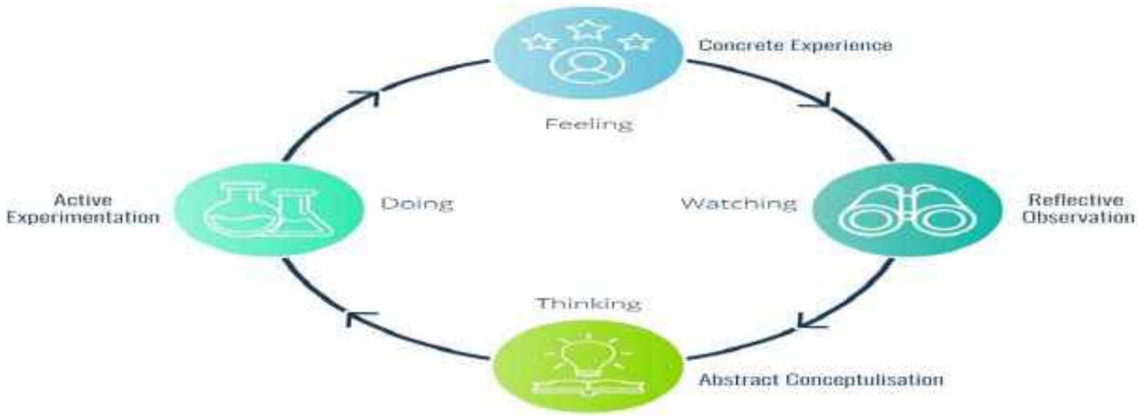

Figure 1: Kold's Experiential Learning Theory

In the Concrete Experience stage, students encounter new situations or reinterpret existing ones, such as engaging with EdTech tools like Canva or WhatsApp Business in a Business Education course. This is followed by Reflective Observation, where students reflect on how these tools were used by lecturers, and whether they helped them connect theory to enterprise-oriented practice. These reflections guide the Abstract Conceptualisation stage, where students build mental models or reframe their understanding of entrepreneurship and digital literacy, possibly through business simulations or e-commerce assignments. Finally, Active Experimentation involves applying these concepts, creating real or prototype business ventures using the tools they have engaged with. This cycle mirrors how EdTechpreneurial pedagogies should ideally function. Kolb further identifies four learning styles that explain students' dominant preferences. Diverging learners, who excel at observation and imaginative thinking, would benefit from group reflections on tech-based business challenges. Assimilating learners, who prioritise conceptual clarity, thrive on structured digital content or LMS-based entrepreneurship models. Converging learners, who are solution-oriented, would engage best through task-based platforms like Trello. Accommodating learners who prefer hands-on experience is likely to respond well to practical tool use, such as setting up online storefronts.

ELT is appropriate for the current study as it validates the need to assess whether Business Education lecturers provide sufficient exposure, reflection, conceptual development, and application opportunities through EdTech tools, key in developing graduates prepared for self-employment in a tech-driven economy.

Review of Empirical Related Studies

Recent empirical investigations in Business Education in Nigeria have emphasised the growing necessity of embedding entrepreneurial capacity into pedagogical delivery. Among the most relevant empirical contributions is the study by Edeh, Odunukwe, Abubakar, Ozurumba, Adeleye and Yumma (2022), which assessed strategies for effective implementation of the Business Education curriculum for self-reliance in South-East Nigeria. This study used a descriptive survey design among university lecturers and identified several barriers to effective curriculum implementation, including limited technological resources and low staff training in

entrepreneurship-infused delivery. While the study provided valuable institutional insight, its lecturer-focused orientation left out student perspectives, which are critical in determining how curriculum implementation translates into actual exposure and self-employment preparedness. Additionally, no specific technological tools were identified as core to entrepreneurial training, making it difficult to assess their integration level.
Alao and Alao (2022) provided one of the few student-centered investigations by exploring the impact of innovative pedagogies on the entrepreneurial empowerment of Business Education students in Lagos tertiary institutions. Their findings emphasized the importance of experiential learning, practical exposures, and digital collaboration tools. However, the study fell short of naming or categorizing specific EdTech tools employed by lecturers or students. It also did not clarify whether the entrepreneurial empowerment students experienced resulted directly from pedagogical exposure or personal initiative. This ambiguity underlines a gap in determining whether EdTechpreneurial practices are embedded in the curriculum or merely co-curricular experiences. The current study addresses this by interrogating students' exposure to such pedagogies as delivered through the curriculum and by their lecturers.

In another critical analysis of technology integration in Nigerian secondary schools, Chidiebere (2020) focused on infrastructural readiness and teachers' attitudes. Though not in the university context, the study offers foundational insight into systemic issues likely mirrored at the tertiary level, such as inadequate funding and limited teacher competencies. Importantly, the study did not consider the entrepreneurial outcomes of technology integration or how tool selection links with self-employment competencies. Thus, the transition from basic ICT familiarity to strategic EdTech use for entrepreneurial training remains uncharted, especially from the student experience angle, which the current study now foregrounds. Similarly, Nwokike and Chukwuma (2019) investigated the integration of new technologies in teaching Business Education in public universities in Enugu State. Their study revealed that the lack of new technology tools and inadequate competencies among lecturers significantly constrained digital adoption. Tools referenced were general-purpose technologies and did not include entrepreneurial platforms such as Google Sites, Canva, or Paystack. Moreover, their study relied solely on business educators' responses, without exploring the learner's side of implementation. By not capturing whether students actually benefited from any implemented technologies, the study highlighted the need for further empirical investigation into how teaching practices translate into learner empowerment, an issue directly tackled by the current study.

The study by Enang and Okute (2019) emphasised the application of new technologies for skill acquisition in tertiary Business Education. It examined how flipped classrooms, personalised learning, and technology-enabled collaboration could support Business Education outcomes. This research offered a more conceptual exploration, citing potential benefits rather than empirically testing actual classroom application or student outcomes. It lacked field data and did not involve either lecturers or students as respondents, which limits its practical implications. Furthermore, while tools like the flipped classroom were mentioned, there was no linkage to entrepreneurship-specific platforms or how students use such tools for business creation.
In comparing these studies, a few commonalities and critical gaps emerge. First, most lecturer-focused studies underscore infrastructural and competence-related barriers but fail to investigate what students actually receive in practice. Second, student-centred studies hint at entrepreneurial gains but do not tie these to specific EdTech tools or assess their alignment with curriculum delivery. Third, conceptual studies and the digital pedagogy paper offer valuable theoretical

insights but lack empirical testing in classroom settings. Moreover, across all the studies, none adopt a dual-focus approach combining technology use with entrepreneurial intent through the lens of students who are at the final phase of the Business Education programme, making them the most reliable evaluators of curriculum implementation. There is also limited clarity on which EdTech tools are actually used in classrooms and whether they are aligned with entrepreneurial skill acquisition.

Methodology

This study adopted a quantitative research design. The study focused on 142 and 45 final-year (400-level) students in the Business Education programme of the University of Lagos and Lagos State University, respectively, who are considered best positioned to assess cumulative exposure to entrepreneurial-oriented EdTech tools. A census sampling technique was employed, involving all the 187 400-level students enrolled in the 2024/2025 academic session of the two universities. This choice was informed by the manageable population size and the need for comprehensive coverage of student perspectives. Data collection was conducted using a researcher-designed questionnaire titled "Students' Assessment of EdTechpreneurial Pedagogies in Business Education Questionnaire (SAEPEBEQ)".

The instrument was divided into five sections. Section A gathered demographic data (3 items). Section B examined students' level of exposure to EdTechpreneurial pedagogies, featuring 5 items that measured frequency and intensity of engagement with technology-supported entrepreneurial learning experiences. Section C focused on identifying the types of EdTech tools and platforms lecturers have used during instructional delivery. This section included 7 items targeting tools such as Canva, Google Sites, Instagram shop, Facebook and WhatsApp Business. Section D assessed students' perception of the impact of EdTechpreneurial pedagogies on their self-employment readiness, using 5 items designed to evaluate confidence in business planning, digital branding, and launching ventures. Lastly, Section E captured the challenges students face in benefiting from these pedagogies. This section comprised 5 items addressing issues such as digital skill gaps, infrastructure, cost, and lecturer support. All items were rated on a 4-point Likert scale ranging from Strongly Agree (4) to Strongly Disagree (1), except for section C, which was rated using yes or no response pattern. For reliability testing, 20 students from the 300-level cohort of the University of Lagos were used in a pilot study. The internal consistency of the instrument yielded a Cronbach's Alpha coefficient ranging from 0.720 to 0.744 for the four sections, indicating an acceptable level of reliability. All data collected were analysed using descriptive statistics, particularly, frequency count and percentage for answering the research questions, and Pearson correlation was used to test the null hypothesis at a 0.05 level of significance.

Results

Table 1: Presentation of Participants' Demographics

Variable	Category	n	%
University	Lagos State University	34	23.8
	University of Lagos	109	76.2
Age	20–23 years	12	8.4
	24–27 years	80	55.9
	28 years above	51	35.7
Running a Business	Yes	37	25.9
	No	106	74.1

Table 1 shows that most respondents (76.2%) attended the University of Lagos, while 23.8% were from Lagos State University. The largest age group was 24–27 years (55.9%), followed by those aged 28 years and above (35.7%), with only 8.4% aged 20–23 years. In terms of business ownership, the majority (74.1%) reported not owning a business, while 25.9% indicated they did. These results suggest that the sample is dominated by older young adults in their mid-to-late twenties, primarily from the University of Lagos, and with limited entrepreneurial engagement, highlighting potential areas for skill development and business-oriented capacity building.

Answering Research Questions

Research Question 1: What is the level of students' exposure to EdTechpreneurial pedagogies in Business Education courses?

Table 2: Students' Exposure to EdTechpreneurial Pedagogies in Business Education Courses

S/N	Item	SD (%)	D (%)	A (%)	SA (%)
1	I have been taught business-related skills using digital tools in my courses.	6 (4.2)	12 (8.4)	83 (58.0)	42 (29.4)
2	I am familiar with how to use digital tools through class teaching.	7 (4.9)	10 (7.0)	100 (69.9)	26 (18.2)
3	During my course of study, my lecturers involve all students in projects that require using digital tools to simulate business.	9 (6.3)	27 (18.9)	77 (53.8)	30 (21.0)
4	Exposure to digital-based entrepreneurship activities in class has helped me understand entrepreneurship.	10 (7.0)	13 (9.1)	85 (59.4)	35 (24.5)

Note: SA = Strongly Agree; A = Agree; U = Undecided; D = Disagree; SD = Strongly Disagree

Table 2 presents a clear picture of students' exposure to EdTechpreneurial pedagogies in Business Education courses. It indicates a high level of student exposure to EdTechpreneurial pedagogies in Business Education courses. Across all items, the majority of respondents selected Agree or Strongly Agree, showing consistent engagement with digital tools for business learning. Notably, 87.4% reported being taught business-related skills using digital tools, while 88.1% were familiar with digital platforms through classroom teaching. Similarly, 74.8% confirmed participation in projects requiring digital tool use to simulate business activities, and 83.9% agreed that exposure to digital-based entrepreneurship activities enhanced their understanding of entrepreneurship. These findings suggest that EdTechpreneurial strategies are actively embedded in course delivery, equipping students with both theoretical knowledge and practical experience. Hence, students appear to receive substantial exposure to technology-driven entrepreneurial learning, positioning them to apply digital tools effectively in real-world business contexts.

Research Question 2: What types of EdTech tools and platforms are lecturers using in the delivery of Business Education content?

Table 3: Students' Exposure to Specific EdTech Tools for Business Education

S/N	EdTech Tool and Purpose	No (n, %)	Yes (n, %)
1	Canva (for design, branding, logo creation)	110 (76.9)	33 (23.1)
2	WhatsApp Business (for teaching advertising & marketing)	94 (65.7)	49 (34.3)
3	Facebook Business (for teaching advertising & marketing)	94 (65.7)	49 (34.3)
4	Google Sites or blogs (for building business pages or portfolios)	104 (72.7)	39 (27.3)
5	Instagram Shop (to showcase products and direct users to external websites or physical stores for transactions)	102 (71.3)	41 (28.7)
6	Wix / WordPress (for practicing business website design and e-commerce training without coding)	82 (57.3)	61 (42.7)
7	Facebook Marketplace (for digital entrepreneurship and product testing)	98 (68.5)	45 (31.5)

Table 3 indicates that most lecturers are not using the listed EdTech tools and platforms in delivering Business Education content, as shown by the consistently higher "No" responses compared to "Yes" responses. For instance, Canva has a low usage rate of 23.1%, while Google Sites/blogs and Instagram Shop are used by only 27.3% and 28.7% of students' lecturers, respectively. Even the relatively more used tools, Wix/WordPress (42.7%), Facebook Business (34.3%), and WhatsApp Business (34.3%), still show that most students (over half) report no exposure to them. However, respondents provide additional opinions as to what EdTech tools are being utilised to teach them business education courses as follows:

Table 4: Other Edtechpreneur Tools used in Business Education

S/N	EdTech Tool / Platform	Frequency	Percentage (%)
1	TikTok	53	37.1
2	Desktop Publishing; Microsoft Word, PowerPoint & Excel; Google Workspace, Mailchimp, Laptop; Jumia/AliExpress	84	58.7

However, the additional tools students say their lecturers "normally use" show a different pattern.

The most frequently mentioned tools, TikTok 53 (37.1%) while useful for general communication, content creation, or data processing, are not primarily entrepreneurial training tools within the Business Education framework. While, the majority 84 (58.7%) commented that Microsoft Office applications, Google Workspace, Mailchimp, laptops, and e-commerce sites like Jumia/AliExpress were used in the process of teaching them. While some of these can support business-related tasks, they are largely general productivity or communication tools rather than platforms that provide authentic entrepreneurial practice.

This pattern suggests that although lecturers may be using various digital tools in class, the integration of core entrepreneurial EdTech tools designed to develop students' skills in branding, marketing, e-commerce, and digital entrepreneurship remains limited. The additional tools list shows a stronger emphasis on administrative and presentation tasks rather than immersive, skills-based experiences in areas like online branding, product development, customer engagement, or digital sales. As a result, students may not be getting adequate exposure to practical, market-relevant digital entrepreneurship platforms, which are central to building 21st-century vocational skills in Business Education.

Research Question 3: What is the perceived impact of EdTechpreneurial pedagogies on students' preparedness for self-employment?

Table 5: Students' Perception of the Impact of EdTechpreneurial Pedagogies on Preparedness for Self-Employment

S/N	Item	SA (%)	A (%)	U (%)	D (%)	SD (%)
1	Due to my classroom exposure, I now feel confident in using digital tools to start my own business.	4 (2.8)	8 (5.6)	19 (13.3)	90 (62.9)	22 (15.4)
2	The tools introduced in class have motivated me to think about starting my own business after graduation.	2 (1.4)	10 (7.0)	13 (9.1)	91 (63.6)	27 (18.9)
3	My classroom experiences have developed my skills to run a business using digital platforms.	5 (3.5)	17 (11.9)	10 (7.0)	89 (62.2)	22 (15.4)
4	EdTechpreneurial strategies in my courses have helped me connect theory to real-life business.	2 (1.4)	8 (5.6)	9 (6.3)	98 (68.5)	26 (18.2)
5	Owing to my classroom experience, I now feel more prepared to launch a digital business immediately after graduation.	3 (2.1)	17 (11.9)	17 (11.9)	84 (58.7)	22 (15.4)

Note: SA = Strongly Agree; A = Agree; U = Undecided; D = Disagree; SD = Strongly Disagree

Table 5 reveals a predominantly negative perception among students regarding the impact of EdTechpreneurial pedagogies on their preparedness for self-employment. For Item 1, only 8.4% (SA = 2.8%, A = 5.6%) of students agreed that their classroom exposure made them confident in using digital tools to start their own business, while a substantial 78.3% (D = 62.9%, SD = 15.4%) disagreed, and 13.3% were undecided. Similarly, in Item 2, just 8.4% agreed that the tools introduced in class motivated them to start a business after graduation, with 82.5% expressing disagreement and 9.1% remaining undecided. For Item 3, only 15.4% agreed that their classroom experiences developed the skills needed to run a digital business, whereas 77.6% disagreed and 7.0% were undecided. In Item 4, the majority (86.7%) disagreed that EdTechpreneurial strategies helped them connect theory to real-life business situations, with only 7.0% agreeing and 6.3% undecided. Finally, Item 5 showed that just 14.0% felt more prepared to launch a digital business immediately after graduation, compared to 74.1% who disagreed and 11.9% who were undecided. Hence, the findings suggest that EdTechpreneurial pedagogies, as currently implemented, are perceived by most students as having limited impact on their readiness for self-employment. While a small fraction acknowledged increased confidence, motivation, or skill development, the overwhelming majority disagreed, indicating a possible gap between the intended outcomes of these pedagogies and their actual influence on students' entrepreneurial preparedness. This points to a need for more practical, immersive, and mentorship-driven approaches that bridge theory with real-world entrepreneurial practice.

Research Question 4: What challenges do students face in benefiting from the integration of EdTechpreneurial pedagogies in Business Education?

Table 6: Perceived Challenges Affecting the Use of EdTechpreneurial Pedagogies for Self-Employment Preparedness

S/N	Item	SD (%)	D (%)	A (%)	SA (%)
1	I lack personal access to laptops or smartphones for business learning.	27 (18.9)	60 (42.0)	38 (26.6)	18 (12.6)
2	Poor internet connectivity limits my use of digital business tools in learning.	13 (9.1)	25 (17.5)	74 (51.7)	31 (21.7)
3	Most lecturers avoid using digital tools in teaching entrepreneurial content.	10 (7.0)	46 (32.2)	72 (50.3)	15 (10.5)
4	The university does not provide enough digital resources or access to entrepreneurship platforms.	8 (5.6)	31 (21.7)	67 (46.9)	37 (25.9)
5	I find it hard to understand or use some digital tools introduced in class.	21 (14.7)	63 (44.1)	50 (35.0)	9 (6.3)

The results in Table 6 highlight several significant challenges that students face in benefiting from the integration of EdTechpreneurial pedagogies in Business Education. For Item 1, a majority of students (60.9%) disagreed with the statement that they lacked personal access to laptops or smartphones, while 39.2% agreed. This indicates that although access to devices is not a universal challenge, a considerable minority still experiences this barrier, which could limit their ability to fully engage with digital entrepreneurial learning. Item 2 reveals that poor internet connectivity is a major challenge, with 73.4% (Agree = 51.7%, Strongly Agree = 21.7%) confirming its negative impact on their use of digital business tools, while only 26.6% disagreed. In Item 3, over half of the respondents (60.8%) agreed that most lecturers avoid using digital tools in teaching entrepreneurial content, suggesting that instructional practices may not consistently support EdTech-driven entrepreneurship learning.

Item 4 further emphasises institutional limitations, with 72.8% of students agreeing that their university does not provide enough digital resources or access to entrepreneurship platforms, highlighting a critical infrastructural gap. Finally, Item 5 shows that 41.3% of students struggled to understand or use some digital tools introduced in class, while the majority (58.8%) did not perceive this as a challenge. This indicates that while technical difficulty is not as widespread as other issues, it still affects a substantial proportion of students. Hence, the findings indicate that the key challenges to benefiting from EdTechpreneurial pedagogies include poor internet connectivity, insufficient institutional provision of digital resources, and inconsistent use of digital tools by lecturers. While device ownership is relatively less problematic, its absence still affects a notable minority.

Test of Hypothesis

Ho$_1$: There is no statistically significant relationship between students' exposure to EdTechpreneurial pedagogies and their perceived preparedness for self-employment.

Table 7: Correlation Analysis showing relationship between students' exposure to EdTechpreneurial pedagogies and their perceived preparedness for self-employment

Variable	N	$\overline{X}$	SD	df	Cal r-value	p-value	Decision
Exposure to EdTechpreneurial Pedagogies (EEP)	143	3.82	.793	141	.249	.056	Ho Accepted
Entrepreneurial Preparedness for Self-Employment		3.84	.702				

***Significant P< .05**

Table 7 shows the Pearson correlation analysis between students' exposure to EdTechpreneurial pedagogies (EEP) and their entrepreneurial preparedness for self-employment. The calculated correlation coefficient (r = 0.249) indicates a weak positive relationship between the two variables. However, the p-value (.056) is greater than the 0.05 significance threshold, meaning the relationship is not statistically significant at the 5% level. This implies that variations in students' exposure to EdTechpreneurial pedagogies do not significantly predict their perceived preparedness for self-employment. Consequently, the null hypothesis (Ho$_1$), which states that there is no statistically significant relationship between students' exposure to EdTechpreneurial pedagogies and their perceived preparedness for self-employment, is accepted.

Discussion of Findings

The findings of this study, when examined alongside existing literature and Kolb's Experiential Learning Theory, consistently point to a single systemic weakness in the teaching of Business Education in Nigerian universities: EdTechpreneurial pedagogies are being introduced in name, but lack the depth and practical application needed to truly prepare students for entrepreneurship. Research question one indicates that students report high exposure to EdTechpreneurial pedagogies, suggesting that digital tools feature in course delivery. However, research question two reveals that lecturers largely rely on general productivity tools such as Microsoft Office and Google Workspace, rather than specialised, market-relevant entrepreneurial platforms like Canva, Google Sites, or e-commerce tools. This pattern reflects earlier findings by Nwokike and Chukwuma (2019) and Edeh et al. (2022), who identified limited lecturer competence and tool selection as key barriers to effective entrepreneurship-oriented technology use. Such a tool choice limits students' opportunities to engage in authentic, venture-driven activities and undermines the entrepreneurial intent embedded in the CCMAS curriculum (NUC, 2023).

Kolb's Experiential Learning Theory helps explain why this tool gap results in the research question three, where students overwhelmingly feel unprepared for self-employment. While the Concrete Experience stage is partially met through exposure to digital tools, subsequent stages, particularly Active Experimentation, remain underdeveloped. Students are rarely tasked with creating real or prototype businesses using the tools, preventing the full cycle of learning that transforms theory into competence. This echoes Alao and Alao's (2022) observation that entrepreneurial empowerment often stems from personal initiative rather than structured pedagogical exposure. The fourth research question highlights the enabling conditions behind this shortfall: poor internet connectivity, inadequate institutional resources, and limited lecturer adoption of entrepreneurial tools, challenges also noted by Chidiebere (2020) and Enang & Okute (2019). These systemic constraints make sustained, practice-based engagement with entrepreneurial technologies difficult.

Finally, the non-significant correlation between exposure and preparedness confirms that nominal exposure alone does not build entrepreneurial capability. In line with Olatunji and Ajero's (2022) argument, the study shows that without intentional, experiential, and tool-specific integration, EdTechpreneurial strategies risk remaining theoretical, leaving the employability and innovation goals of Business Education unmet.

Conclusion

This study concludes that while EdTechpreneurial pedagogies are visibly integrated into Business Education, their implementation lacks the depth and authenticity required to develop entrepreneurial competence. Findings show high student exposure to digital tools but a heavy reliance on generic platforms rather than market-relevant entrepreneurial technologies. This gap, combined with infrastructural deficiencies, limited lecturer adoption, and inadequate practical engagement, contributes to low self-employment preparedness. The non-significant correlation between exposure and readiness reinforces that theoretical familiarity alone is insufficient. Without stronger integration of hands-on, skills-based EdTechpreneurial practices supported by institutional resources, Business Education risks producing graduates unready for the demands of entrepreneurship.

Recommendations

Based on the findings of this study, it was recommended that:

1. Institutions must prioritise investment in reliable internet connectivity, updated digital facilities, and dedicated technical support.
2. Targeted professional development programmes should equip lecturers with the skills to identify, evaluate, and integrate genuine EdTechpreneurial platforms into teaching.

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BASELINE STUDY FOR THE DESIGN AND DEVELOPMENT OF "TEECHA" A PROFESSIONAL DEVELOPMENT PLATFORM FOR IN-SERVICE TEACHERS IN NIGERIA

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Abstract
This paper presents a baseline study conducted to inform the design and development of "TEECHA," an online professional development platform for teachers in Lagos, Nigeria. Similar to established platforms like Udemy, Coursera, and edX, TEECHA aims to address the evolving professional development needs of educators. The study investigates current professional development needs and preferences, familiarity with and utilization of existing online platforms, preferred payment models (one-time payment vs. subscription), and specific desired topics for enhancing teaching skills among teachers in Lagos, Nigeria. Utilizing a mixed-methods approach, this research provides critical insights into the landscape of teacher professional development in the region, offering data-driven recommendations for the effective design and implementation of the TEECHA platform.

Keywords Teacher Professional Development, Online Learning Platforms, TEECHA, Educational Technology, Teacher Training

Introduction
The landscape of education is in constant flux, driven by technological advancements, evolving pedagogical approaches, and the dynamic needs of learners. In this rapidly changing environment, continuous professional development (PD) for teachers is not merely beneficial but essential for maintaining high-quality instruction and fostering student success (Zhang et al., 2022). Traditional models of professional development, often characterized by one-off workshops or infrequent seminars, have increasingly been recognized as insufficient to meet the complex and ongoing learning needs of educators. The advent of online learning platforms has emerged as a transformative solution, offering unprecedented flexibility, accessibility, and a diverse range of learning opportunities for teachers worldwide.

The global shift towards digital learning, significantly accelerated by recent global events, has underscored the critical role of online platforms in facilitating continuous learning for educators. These platforms, akin to popular Massive Open Online Course (MOOC) providers such as Udemy, Coursera, and edX, offer scalable and adaptable solutions for professional growth (Hertz & Clemson, 2022). For teachers, online professional development presents an opportunity to engage with new methodologies, acquire digital literacy skills, and stay abreast of curriculum changes without the constraints of geographical location or rigid schedules. This flexibility is particularly pertinent in contexts where access to traditional PD opportunities may be limited or cost-prohibitive. In Nigeria, and specifically in Lagos, a bustling metropolitan hub with a large and diverse educational sector, the need for effective and accessible teacher professional development is paramount. The quality of education is directly linked to the competence and continuous learning of its teaching workforce. However, challenges such as large class sizes, limited resources, and varying levels of digital infrastructure can impede the effective delivery of traditional PD programs. Online platforms, therefore, hold immense potential to bridge these gaps, offering a viable pathway for thousands of teachers to enhance their skills and pedagogical practices (Oubibi et al., 2024).

Recognizing this critical need and the transformative potential of online learning, the "TEECHA" platform is being developed as a dedicated online professional development resource for teachers in Lagos, Nigeria. TEECHA aims to provide a comprehensive and user-friendly environment where educators can access high quality training modules, collaborate with peers, and acquire certifications relevant to their professional growth. To ensure the platform's design and content are optimally aligned with the actual needs and preferences of its target users, a baseline study is indispensable. This study serves as a foundational inquiry, gathering empirical data to inform the strategic development of TEECHA.

Research Questions

This paper presents the findings of a baseline study conducted to understand the current landscape of teacher professional development in Lagos, Nigeria. Specifically, it addresses four key research questions:

(1) What are the current professional development needs and preferences of teachers in Lagos, Nigeria, particularly concerning online learning platforms?

(2) To what extent are teachers in Lagos, Nigeria, familiar with and utilizing existing online platforms for professional development?

(3) What are the professional development platforms Nigerian Teachers are aware of?

(4) What are the preferred models (e.g., one-time payment vs. subscription) for accessing professional development content among teachers in Lagos, Nigeria?

(5) What specific topics or areas of professional development are most desired by teachers in Lagos, Nigeria, for enhancing their teaching skills?

The insights gleaned from this research will directly guide the design, content curation, and operational strategies of the TEECHA platform, ensuring its relevance, effectiveness, and sustainability in supporting teacher excellence in the region.

Literature Review

The concept of professional development for teachers has evolved significantly over the past few decades, moving from traditional, often isolated, training sessions to more continuous, collaborative, and context-specific approaches (Guskey, 2002). Early models of professional development frequently focused on disseminating new information or skills in a top-down manner, with limited attention to the practical application or long-term impact on teaching practices. However, research has increasingly highlighted the importance of professional development that is sustained, embedded in practice, collaborative, and responsive to the specific needs of educators and their students (Darling-Hammond et al., 2017). The rise of online learning platforms has presented a new frontier for delivering such professional development, offering unprecedented opportunities for flexibility and access.

Online learning platforms have transformed various sectors, including education, by providing scalable and accessible avenues for knowledge acquisition and skill development. Platforms like Coursera, Udemy, and edX have democratized access to higher education and specialized training, demonstrating the efficacy of online modalities for diverse learning needs (Zhang et al., 2022). In the context of teacher professional development, online platforms offer several advantages, including the ability to overcome geographical barriers, provide asynchronous learning opportunities, and offer a wide array of specialized courses that might not be available locally (Sari & Prahmana, 2022). This flexibility is particularly crucial for in-service teachers who often juggle demanding schedules and limited time for traditional face to-face training.

The effectiveness of online professional development for teachers is contingent upon several factors, including the quality of the platform, the relevance of the content, and the pedagogical design of the learning experiences. Research by Zhang et al. (2022) emphasizes that the technical quality, content quality, and service quality of online learning platforms are critical determinants of teacher satisfaction and learning outcomes. Their study highlights that optimizing technical aspects (e.g., design style, tool functions, operation efficiency) and service quality can significantly enhance the learning experience, sometimes even more so than content optimization alone. This suggests that a well-designed and user-friendly platform is as important as the content it delivers.

Furthermore, the integration of interactive technologies and the fostering of online learning communities play a vital role in enhancing the efficacy of online teacher professional development. Oubibi et al. (2024) in their systematic review on interactive technologies in online teacher education in Africa, underscore the necessity for sustained professional development that equips teachers with the skills to effectively integrate these technologies into their practice. They also point out challenges such as equitable access to online platforms, which need to be addressed for broader impact. The ability for teachers to collaborate, share experiences, and receive feedback within an online community can significantly deepen their learning and promote the transfer of new knowledge into classroom practice (Sümer, 2021).

Regarding payment models, the literature suggests a varied landscape. While some professional development opportunities are publicly funded or provided by educational institutions, many online platforms operate on a fee-for-service basis, offering both one-time payment options for individual courses and subscription models for broader access to content libraries. The preference for one model over another often depends on factors such as the perceived value of the content, the financial capacity of the teachers or their institutions, and the long-term professional development goals (Hertz & Clemson, 2022). Understanding these preferences is crucial for the sustainability and accessibility of platforms like TEECHA, ensuring that the chosen model aligns with the economic realities and expectations of the target audience in Lagos, Nigeria.

Methodology

This study adopted a descriptive survey research design to gather empirical data on the professional development needs, preferences, and platform usage patterns of teachers in Lagos, Nigeria. The approach was considered appropriate as it enabled the researchers to obtain quantitative data that could be analyzed to describe current trends and inform the design of the TEECHA platform. The target population comprised in-service teachers across various public and private schools in Lagos, representing diverse educational levels and subject specializations. A purposive sampling technique was employed to ensure that respondents had prior exposure to, or interest in, professional development activities. Data were collected from 38 teachers using a structured questionnaire developed by the researchers, which included both closed-ended and multiple-response items. The instrument was validated by experts in educational technology and teacher development, and its reliability was confirmed using Cronbach's alpha, yielding a coefficient of 0.82, indicating high internal consistency. The questionnaire was organized into sections corresponding to the study's research questions, covering areas such as professional development needs, familiarity with existing platforms, awareness of available platforms, preferred payment models, and desired training topics. Data collection was conducted both physically and through online distribution to maximize participation. Responses were coded and analyzed using the Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize responses, while chi-square tests were applied to examine associations between categorical variables, such as familiarity and utilization of platforms. Multiple response analysis was employed to present results where respondents could select more than one option. The findings from these analyses provided a clear and evidence-based foundation for the strategic design and development of the TEECHA platform.

Results

This section presents the findings from the analysis of the SPSS data, addressing each of the five research questions. The results are primarily presented through frequency distributions, providing insights into the professional development landscape among teachers in Lagos, Nigeria.

Research Question 1: What are the current professional development needs and preferences of teachers in Lagos, Nigeria, particularly concerning online learning platforms?

Table 1: Professional Development Needs and Preferences of Teachers (N = 38)

Needs/Preferences	Mean	Std. Deviation	Rank
Training in online teaching tools	4.55	0.58	1
Classroom management in virtual environments	4.47	0.66	2
Assessment and feedback in online learning	4.34	0.72	3
Curriculum adaptation for e-learning	4.26	0.75	4
Digital content creation skills	4.13	0.77	5

The analysis in Table 1 reveals that teachers in Lagos, Nigeria, have high professional development needs and preferences across various aspects of online learning platforms. Training in online teaching tools emerged as the highest priority, with a mean score of 4.55 (SD = 0.58), indicating that most respondents rated this need as very important. Classroom management in virtual environments ranked second (M = 4.47, SD = 0.66), reflecting the perceived necessity of maintaining effective learning environments online. Assessment and feedback in online learning followed closely (M = 4.34, SD = 0.72), while curriculum adaptation for e-learning had a slightly lower mean of 4.26 (SD = 0.75). Digital content creation skills, though still important, ranked last with a mean score of 4.13 (SD = 0.77). These results suggest that while all the identified areas are considered relevant, teachers place the greatest emphasis on acquiring technical and pedagogical competencies for delivering effective online instruction.

Research Question 2: To what extent are teachers in Lagos, Nigeria, familiar with and utilizing existing online platforms for professional development?

Table 2: Familiarity with Online Platforms (N = 38)

Familiarity Level	Frequency	Percentage (%)
Very familiar	11	28.9
Somewhat familiar	17	44.7
Not familiar	10	26.3

Chi-Square Test of Familiarity vs. Utilization

Value	Df	Asymp. Sig. (2-sided)
Chi-Square	8.214	4

The results in Table 2 indicate that a considerable proportion of teachers in Lagos, Nigeria, are at least moderately familiar with existing online platforms for professional development. Specifically, 28.9% reported being very familiar, 44.7% were somewhat familiar, while 26.3% indicated no familiarity. The Chi-Square test ($\chi^2 = 8.214$, df = 4, $p < 0.05$) reveals a statistically significant association between teachers' familiarity with these platforms and their actual utilization for professional development activities. This suggests that the more familiar teachers are with online platforms, the more likely they are to use them, highlighting the importance of awareness and exposure in promoting adoption of digital learning resources for professional growth.

Research Question 3: What are the professional development platforms Nigerian Teachers are aware of?

Table 3: Awareness of Professional Development Platforms (Multiple Response)

Platform	Frequency	Percentage of Cases (%)
Coursera	24	63.2
Udemy	31	81.6
Khan Academy	18	47.4
Edx	13	34.2

Table 3 shows that teachers in Lagos, Nigeria, are aware of a variety of professional development platforms, with Udemy having the highest level of awareness at 81.6% of respondents. Coursera follows closely, with 63.2% indicating familiarity, while Khan Academy is known by 47.4% of teachers. Awareness of Edx is relatively lower, with only 34.2% of respondents reporting knowledge of the platform. These findings suggest that while some platforms, such as Udemy and Coursera, have gained significant recognition among teachers, others remain less prominent, indicating potential opportunities for increased promotion and integration of diverse online learning platforms in teacher professional development.

Research Question 4: What are the preferred models (e.g., one-time payment vs. subscription) for accessing professional development content among teachers in Lagos, Nigeria?

Table 4: Preferred Payment Model (N = 38)

Model	Frequency	Percentage (%)
One-time payment	14	36.8
Monthly subscription	18	47.4
Annual subscription	6	15.8

Table 4 reveals that the most preferred payment model for accessing professional development content among teachers in Lagos, Nigeria, is the monthly subscription option, chosen by 47.4% of respondents. This is followed by a one-time payment preference, reported by 36.8% of teachers, while only 15.8% favored an annual subscription model. The findings indicate that teachers tend to prefer payment structures that offer flexibility and affordability over longer-term commitments, suggesting that professional development providers may achieve higher participation rates by offering cost-spread, short-term subscription options.

Research Question 5: What specific topics or areas of professional development are most desired by teachers in Lagos, Nigeria, for enhancing their teaching skills?

Table 5: Desired Professional Development Topics

Topic	Frequency	Percentage (%)
ICT integration in teaching	30	78.9
Digital assessment tools	26	68.4
Inclusive education strategies	21	55.3
Online student engagement	28	73.7
Data-driven teaching improvement	19	50.0

Table 5 indicates that ICT integration in teaching is the most desired professional development topic among teachers in Lagos, Nigeria, with 78.9% of respondents expressing interest. Online student engagement follows closely at 73.7%, highlighting a strong demand for strategies to maintain active participation in virtual learning environments. Digital assessment tools are also a priority for 68.4% of teachers, while inclusive education strategies are desired by 55.3%, reflecting interest in accommodating diverse learners. Data-driven teaching improvement, though important, had the lowest demand at 50.0%. Overall, the results suggest that teachers place the greatest emphasis on technology-enabled instruction and student engagement skills to enhance their teaching effectiveness in digital contexts.

Discussion of Findings

The findings of this study reveal that Lagos teachers have a strong preference for professional development opportunities that focus on practical and technology-driven teaching enhancements, such as ICT integration in teaching (78.9%), online student engagement (73.7%), and digital assessment tools (68.4%). This aligns with the global trend where teachers increasingly recognize the role of digital tools in improving instructional delivery and student learning outcomes (Koehler et al., 2017; Tondeur et al., 2021). The high demand for ICT and online engagement training suggests a growing acknowledgment among Nigerian educators that digital literacy is no longer optional but an essential competency in 21st-century classrooms. This corroborates the findings of Omodan and Ige (2022), who emphasized that targeted professional development in technology use significantly enhances teacher confidence and pedagogical effectiveness.

Another notable finding is that while inclusive education strategies (55.3%) and data-driven teaching improvement (50.0%) were less frequently selected compared to technology-related topics, they still represent critical areas of interest. This pattern suggests that while teachers are eager to strengthen technological skills, there is also an underlying recognition of the need to address diverse learner needs and apply evidence-based decision-making in teaching. Previous studies have similarly reported that effective professional development should integrate both digital competencies and inclusive pedagogical approaches to maximize its impact on teaching quality (Darling-Hammond et al., 2017; Aladejana & Ademola, 2020). These findings imply that a balanced professional development framework—combining digital proficiency with inclusive and data-informed teaching—is likely to yield better educational outcomes in Lagos schools.

Furthermore, the teachers' preferences align with the broader educational reform agenda in Nigeria, which emphasizes competency-based curricula, technology-enhanced learning, and learner-centered pedagogy (Federal Ministry of Education, 2021). Similar trends have been observed in other developing countries where digital transformation in education is accelerating due to both policy mandates and post-pandemic instructional shifts (Trust et al., 2020; Mpungose, 2022). Therefore, the insights from this study not only inform the development of the TEECHA platform but also offer valuable guidance for policymakers, teacher training institutions, and educational technology developers seeking to provide relevant, impactful, and sustainable professional development solutions in Nigeria and similar contexts.

Conclusion

The study has shown that Lagos teachers prioritize professional development opportunities that enhance their digital competencies, particularly in ICT integration, online student engagement, and digital assessment tools. This reflects an evolving recognition of the central role that technology plays in modern teaching and learning environments. While interest in inclusive education strategies and data-driven decision-making was slightly lower, these areas remain essential for fostering equity and evidence-based instructional improvements. The findings highlight the need for a professional development framework that not only addresses technological proficiency but also integrates inclusive practices and data utilization for more effective and responsive teaching.

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AVAILABILITY AND ACCESSIBILITY OF ASSISTIVE TECHNOLOGY TOOLS FOR YOUTH LIVING WITH DISABILITIES (YLWD) IN THE ERA OF DIGITAL TRANSFORMATION

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Abstract
This study examined the availability and accessibility of assistive technology (AT) tools and digital technologies for youth living with disabilities (YLWD) in selected special care homes in Lagos, Nigeria, within the context of ongoing digital transformation. A descriptive research design was employed, using a structured questionnaire administered to 23 respondents from Modupe Cole Homes and Step One Special Care Home. Data were analyzed using frequency distributions and descriptive statistics. Findings revealed a critical scarcity of assistive technologies, with the wheelchair equipped with a digital navigation aid being the most available (21.5%), while other tools such as screen reader software, hearing aids, adaptive keyboards, and augmentative and alternative communication devices were each reported by less than 10% of respondents. Furthermore, access to digital technologies was found to be severely limited, as more than half (56.6%) of respondents reported having no access to smartphones, computers, internet connectivity, or tablets. These results highlight a persistent digital divide and underscore the urgent need for targeted interventions, including policy reforms, infrastructural investment, and training initiatives, to enhance AT provision and digital access for YLWD. Addressing these gaps will be crucial in promoting social inclusion, educational opportunities, and economic empowerment for this marginalized population.

Keywords: Assistive technology, youth living with disabilities, digital accessibility, special care homes, Lagos, digital divide, inclusive education

Introduction

The pervasive influence of digital technology has fundamentally reshaped global societies, fostering unprecedented levels of connectivity and access to information. This digital transformation, while offering vast opportunities for education, communication, and socio-economic participation, presents a complex landscape for vulnerable populations, particularly youth living with disabilities (YLWD) (McNicholl et al., 2021; Fernández-Batanero & Montenegro-Rueda, 2022). The inherent promise of digital inclusion often clashes with persistent barriers, which can exacerbate existing inequalities and impede the full integration of YLWD into the digital sphere (Iadarola et al., 2024; Poddar et al., 2024). Assistive technology (AT) emerges as a pivotal intervention in this context, providing specialized tools and solutions designed to augment the functional capabilities of individuals with disabilities and foster greater independence (McNicholl et al., 2021; Fernández-Batanero & Montenegro-Rueda, 2022).

Globally, the imperative for disability inclusion has increasingly underscored the transformat ive potential of technology as an enabler. International frameworks, such as the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD), unequivocally advocate for equitable access to quality education and information, emphasizing the indispensable role of assistive technologies in realizing these objectives (UNCRPD, 2006). However, the practical implementation of these principles exhibits considerable variability across diverse geographical contexts, with many developing nations facing significant hurdles due to infrastructural deficits, economic constraints, and limited awareness (Adewale & Odewumi, 2024; World Education Blog, 2024). In Nigeria, a nation experiencing rapid technological advancement and urbanization, a nuanced understanding of the AT landscape and digital access for YLWD is crucial for formulating effective policy and targeted intervention strategies (Waldenu, 2024; UNESCO, 2024).

Assistive technologies encompass a broad spectrum of devices and services, ranging from fundamental low-tech aids, such as magnifiers and adapted writing tools, to sophisticated high-tech solutions, including advanced screen readers, voice recognition software, and specialized augmentative and alternative communication (AAC) devices (Iadarola et al., 2024; Poddar et al., 2024). For YLWD, these diverse tools are instrumental in facilitating learning processes, enhancing mobility, improving communication efficacy, and enabling more robust participation in daily activities (Fernández-Batanero & Montenegro-Rueda, 2022; ResearchGate, 2024). Nevertheless, the effectiveness of AT is not solely contingent upon its mere existence but critically depends on its comprehensive accessibility, which encompasses factors such as affordability, widespread availability, and the provision of adequate support systems for proper utilization and maintenance (PMC, 2024; World Forgotten Children Foundation, 2024). The ongoing digital transformation further complicates this dynamic by introducing novel technological paradigms that may not be inherently accessible, thereby creating both new challenges and opportunities for YLWD (ACT, 2024; Technical.ly, 2024).

This study endeavors to systematically investigate the contemporary status of assistive technology tools for YLWD in Lagos, Nigeria, by addressing two primary research questions. Firstly, it aims to meticulously identify the specific types of assistive technologies currently available to youth living with disabilities within this context. Secondly, it seeks to comprehensively examine the extent to which YLWD possess access to essential digital technologies, including but not limited to smartphones, computers, and internet connectivity. By meticulously collecting empirical data from selected special care homes in Lagos, this research intends to generate invaluable insights into existing disparities and prospective avenues for enhancement, ultimately contributing to the cultivation of more inclusive and equitable digital environments for YLWD in the region.

Research Questions

Research Question 1: What are the available assistive technologies for youth living with disabilities?

Research Question 2: To what extent do Youth living with Disabilities (YLWD) have access to digital technologies (such as smartphones, computers, and the internet)?

Literature Review

Assistive Technology (AT) has long been recognized as a critical enabler for individuals with disabilities, facilitating their participation in education, employment, and daily life. Early literature on AT focused primarily on its functional benefits, demonstrating how various devices could compensate for impairments and enhance independence (Alper & Raharinirina, 2006). This foundational understanding has evolved to encompass a broader perspective, recognizing AT not merely as a tool but as an integral component of inclusive environments. Recent systematic reviews highlight that AT can promote significant educational, psychological, and social benefits for students with disabilities in higher education, although successful implementation often depends on factors beyond the technology itself, such as user training and support systems (McNicholl et al., 2021). Furthermore, studies have shown that the effective use of AT can increase the inclusion and accessibility of students with disabilities in various educational settings, despite persistent barriers like inadequate teacher training and resource limitations (Fernández-Batanero & Montenegro-Rueda, 2022).

The landscape of AT has been significantly reshaped by rapid advancements in digital technology. Modern AT solutions increasingly leverage digital platforms, software, and connectivity to offer more sophisticated and integrated support. This includes a wide array of digital tools, from screen readers and voice recognition software for individuals with visual impairments to specialized communication applications for those with speech difficulties. The integration of artificial intelligence (AI) into AT is also emerging as a transformative area, promising more personalized and adaptive solutions (Ang, 2025). However, the effectiveness of these digital ATs is intrinsically linked to digital accessibility, which refers to the ability of people with disabilities to perceive, understand, navigate, and interact with digital content and technologies. Barriers to digital accessibility can arise from poorly designed interfaces, lack of compatibility with AT, or insufficient digital literacy among users (Chadli et al., 2021).

The concept of digital accessibility extends beyond the mere provision of AT to encompass the broader design of digital environments. Inclusive design principles advocate for the creation of digital products and services that are inherently usable by all, regardless of ability, thereby reducing the need for specialized AT in some instances. Despite growing awareness, significant challenges persist in achieving universal digital accessibility. Research indicates that many web platforms and digital services still present substantial barriers for individuals with various disabilities, including those with cognitive impairments (Kulkarni, 2019). The digital divide, often characterized by disparities in access to internet, devices, and digital literacy, further exacerbates these issues, particularly in developing regions. For youth with disabilities, this digital exclusion can limit educational opportunities, social engagement, and future employment prospects (Venkatesan, 2023).

In the context of developing countries like Nigeria, the challenges of AT availability and digital accessibility are compounded by unique socio-economic and infrastructural factors. While there is a global push for digital transformation, the benefits often do not reach marginalized populations due to limited internet penetration, high costs of devices, and a lack of localized support for AT. Studies on digital inclusion in such regions highlight the need for context-specific interventions that address not only the technological gaps but also the socio-cultural barriers to adoption (Boot et al., 2018). Understanding the specific experiences of YLWD in Lagos, a rapidly urbanizing city, provides a crucial lens through which to examine these broader issues of digital equity and inclusion. This study aims to contribute to this understanding by investigating the current state of AT availability and digital access for YLWD in special care homes within this context.

Methodology

This study employed a descriptive research design to investigate the availability and accessibility of assistive technology tools and digital technologies for Youth Living with Disabilities (YLWD) in Lagos, Nigeria. The primary data collection instrument was a structured questionnaire, designed to gather information on the types of assistive technologies utilized, the frequency of digital technology use, perceived barriers to access, and the overall impact of these technologies on the lives of YLWD. The questionnaire comprised both closed-ended and open-ended questions to capture quantitative data amenable to statistical analysis and qualitative insights into the experiences of the respondents.

The target population for this study comprised Youth Living with Disabilities residing in special care homes in Lagos, Nigeria. A purposive sampling technique was utilized to select two prominent special care homes in Lagos: Modupe Cole Homes and Step One Special Care Home. These institutions were chosen due to their established presence in providing care and support for individuals with various disabilities, thus offering a suitable environment for data collection. Within these homes, a total of 23 respondents participated in the study. Specifically, 11 respondents were drawn from Modupe Cole Homes, and 12 respondents were from Step One Special Care Home. The selection of individual participants within each home was based on their willingness to participate and their ability to comprehend and respond to the questionnaire, with assistance provided by caregivers where necessary.

Prior to data collection, ethical approval was obtained from relevant authorities, and informed consent was secured from the management of both Modupe Cole Homes and Step One Special Care Home. For participants who were minors or had cognitive impairments, informed consent was obtained from their legal guardians or primary caregivers. The questionnaires were administered directly to the respondents by trained research assistants, who provided clear explanations of the questions and offered assistance to ensure accurate responses. Data collection was conducted over a period of two weeks, allowing sufficient time for participants to complete the questionnaires at their convenience and minimizing disruption to their daily routines. Confidentiality and anonymity of the participants were strictly maintained throughout the data collection process.

Upon completion of data collection, the responses from the questionnaires were collated and coded. Quantitative data, such as the types of assistive technologies used and the frequency of digital technology access, will be analyzed using descriptive statistics, including frequencies, percentages, means, and standard deviations. This will provide a clear overview of the current landscape of AT availability and digital access among the surveyed population. Qualitative data obtained from the open-ended questions will be subjected to thematic analysis to identify recurring themes and patterns related to the experiences, challenges, and perceptions of YLWD regarding assistive and digital technologies. The findings from both quantitative and qualitative analyses will be integrated to provide a comprehensive understanding of the research questions.

Results

Research Question 1: What are the available assistive technologies for youth living with disabilities?

Table 1: Frequencies of Available Assistive Technologies

Assistive Technology Tool	Frequency	Percentage (%)
Screen Reader Software	1	4.3
Braille Display/Books	2	8.7
Hearing Aids	1	4.3
Speech-to-Text Software	2	8.7
Adaptive Keyboards/Mouse	1	4.3
Wheelchair with Digital Navigation Aid	5	21.5
Augmentative and Alternative Communication	1	4.3
None Available	10	43.4
Total	23	100

The analysis in Table 1 reveals that the availability of assistive technologies for youth living with disabilities in the sampled special care homes is generally low. The most frequently available device was the wheelchair with a digital navigation aid, reported by 21.5% of respondents. Braille display/books and speech-to-text software each accounted for 8.7%, while screen reader software, hearing aids, adaptive keyboards/mouse, and augmentative and alternative communication devices were each reported by only 4.3% of respondents. Notably, a substantial proportion (43.4%) indicated that no assistive technologies were available to them. These findings suggest a significant gap in the provision of essential assistive tools, which could limit the educational, communicative, and mobility opportunities for youth living with disabilities in the study area.

Research Question 2: To what extent do Youth living with Disabilities (YLWD) have access to digital technologies (such as smartphones, computers, and the internet)?

Table 2: Frequencies of Access to Digital Technologies

Digital Technology	Frequency	Percentage (%)
Smartphone	4	17.4
Computer/Laptop	3	13.0
Internet Connectivity	2	8.7
Tablet Device	1	4.3
None Accessible	13	56.6
Total	23	100.0

The results in Table 2 indicate that access to digital technologies among youth living with disabilities in the surveyed special care homes is severely limited. Smartphones were the most commonly accessible device, reported by only 17.4% of respondents, followed by computers/laptops at 13.0% and internet connectivity at 8.7%. Tablet devices had the lowest accessibility, with just 4.3% of respondents indicating they had access. Alarmingly, more than half of the respondents (56.6%) reported having no access to any digital technology at all. This highlights a pronounced digital divide, which may hinder the ability of YLWD to participate fully in educational, social, and economic opportunities facilitated by the digital environment.

Discussion

The findings from this study reveal a profound scarcity in the availability and accessibility of assistive technologies and digital devices for youth living with disabilities in the surveyed special care homes. The low prevalence of essential tools such as screen reader software, Braille displays, hearing aids, and adaptive input devices underscores a significant gap in the provision of resources that are critical for enhancing independence, communication, and learning outcomes (Fernández-Batanero & Montenegro-Rueda, 2022; McNicholl et al., 2021). The fact that 43.4% of respondents reported no access to any assistive technology is particularly concerning, as it suggests systemic neglect in addressing the unique needs of this population. These results align with previous research highlighting infrastructural deficits, limited funding, and inadequate awareness as major barriers to the adoption of assistive technologies in developing contexts (Boot et al., 2018; Adewale & Odewumi, 2024). Such constraints not only impede educational inclusion but also restrict the ability of YLWD to engage fully in everyday social and vocational activities.

Similarly, access to digital technologies, including smartphones, computers, internet connectivity, and tablets, was found to be markedly low, with over half (56.6%) of respondents lacking access to any device. This reflects a persistent digital divide that continues to marginalize individuals with disabilities, particularly in low-resource settings (Venkatesan, 2023; Chadli et al., 2021). Digital technologies have been widely recognized as enablers of social participation, information access, and skill development, yet their benefits remain out of reach for many YLWD due to affordability issues, infrastructural limitations, and inadequate policy support (Kulkarni, 2019; Poddar et al., 2024). The observed disparities in this study resonate with the call for targeted interventions that not only increase the provision of digital devices but also ensure sustainable access through internet affordability, user training, and inclusive design strategies (Fernández-Batanero & Montenegro-Rueda, 2022; Ang, 2025). Without such measures, the digital transformation risks deepening existing inequalities rather than bridging them.

Conclusion

In conclusion, the study demonstrates that youth living with disabilities in the surveyed special care homes experience critical limitations in both the availability of assistive technologies and access to digital devices, with a substantial proportion having no access at all. This scarcity not only hampers their educational opportunities but also restricts their social participation and potential for economic empowerment in an increasingly digital world. Addressing these gaps will require coordinated efforts from policymakers, educators, technology providers, and disability advocates to ensure equitable provision, affordability, and training in the use of assistive and digital technologies, thereby fostering greater inclusion and reducing the digital divide for this vulnerable population.

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EFFECT OF GAMIFICATION ON THE ACHIEVEMENT OF SENIOR SECONDARY SCHOOL STUDENTS' MATHEMATICS IN KONTAGORA, NIGER STATE

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Abstract
This study investigated the effects of Mathematics Gamification Instructional Package on the achievement of senior secondary school students in mathematics in in Kontagora, Niger State. Two research questions and hypotheses guided the study. The population of this study comprised 5287 senior secondary school SS II mathematics students and intact class sample of 87 students (52 male and 35 female) was used for the study. A pre-test post-test quasi experimental design was used. Instruments titled mathematics achievement tests (MAT) was used for data collection. The obtained data were analysed with mean and standard deviations. These were used to answer the research questions while t-test was used to test the hypotheses. It was found that Mathematics Gamification Instructional Package (MGIP) significantly improved students' academic achievement more than conventional methods. However, Mathematics Gamification Instruction Package did not affect achievent based on gender. The study concluded that implementing Mathematics Gamification Instructional Package could perhaps enhance students' achievement positively at senior secondary school mathematics level. Based on these findings, it was recommended that senior secondary schools mathematics students should adopt Mathematics Gamification Instruction Package in teaching and learning of mathematics, since it improves students' academic achievement and gender friendly.

Keywords: **Gamification, Mathematics,**

Introduction

Gamification is one of the most important technology trends. The term itself comes from the digital media industry and was used for the first time in 2008, but its wider usage started two years later. Authors of academic research papers on one side and professional industry reports on the other side agree on the general definition of gamification as the integration of gaming dynamics in non-gaming environments (Zichermann, 2011). Gamification is a relatively new concept but an old practice. Games and the elements that make up games have been incorporated into other areas of life throughout history. This is particularly true of education where the need to ensure student interest and participation has meant that game mechanics such as challenges, rewards, group tasks, puzzles have become core teaching tools. Games and game elements have been be used as tools for learning as they help simulate real-life situations, in safe and often entertaining environment and they often tend to engage players and participants so much that they are emotionally immersed in the process, thereby enjoying the task and challenges it offers (Nwachukwu and Johnson, 2020). As a new mode of teaching and learning, the principal appeal of gamification is the liberty that it provides students and teachers as encapsulated by the four freedoms: the freedom to fail, freedom to experiment, freedom of effort and freedom to self-express. Those freedoms represent a welcome pedagogical shift for those students whose educational potential is being hampered by conventional teaching methods. Teachers today still face difficulties in keeping their students engaged and motivated to learn in the classrooms.

Hugos (2012) found in their study that most teachers are still bound to conventional teaching methods and very much preferred the teacher-centered approach which resulted in negative impact on students' intrinsic motivation and engagement to learn within the classroom walls. Research abounds on the factors militating against the academic performance of senior secondary school students in mathematics. Adeniji and Abubakar (2019) asserts some of such factors include but are not limited to; lack of problem-solving skills, lack of interest by students and methods of teaching such as the traditional chalk-and-talk method. Having the 21st century learners fill the classroom, the task for educators due to the learners' profile and characteristics have changed. These learners want to be challenged and engaged through a learning process which connects them to a different learning process. Educational institutions the world over have recognized the salient roles technology plays in the learning process and environment. Hence, this has made the business of education in the developed world highly hinged on digital technology, specifically, gamification in teaching and learning process. With technological advancements, learning has changed; fun, engagement and interaction are now keys to make learning interesting for today's 21st century learners.

Deterding *et al* (2011) Opined Gamification as the application of game-design elements to non-game contexts with the intention of modifying behaviours, increasing fidelity or motivating and engaging people. Gamification applies elements associated with video games (game mechanics and game dynamics) in non-game applications. It aims to increase people's engagement and to promote certain behaviors. Although, the concept has been explored primarily in the marketing area, the potential of its application has been extended to other areas such as Health, Environment, Government or Education (Jorge,*et al.*, 2015).

Kapp (2012) defined gamification as the process of using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems. He further stressed that there are two types of gamification which include structural gamification and content gamification. Structural gamification is the application of game elements to propel a learner through content with no alteration or changes to the content itself. While content gamification is the process of integrating game-like elements into content, such as educational material to enhance user engagement and make it more interactive and enjoyable.

Statement of the Problem

Learning in the secondary classroom is something that is usually not considered fun or entertaining in Kontagora, however, to engage in the act of learning which has to do with gaining knowledge and skill, a learner must be motivated and engaged. There is a tremendous need to make the learning process challenging, engaging and motivating for the 21st century learners and this has become a major challenge for the mathematics teachers. Mathematics is a subject in the curriculum of secondary schools education in Nigeria, aimed at helping students acquire knowledge and skills. The relevance of mathematics in science and technological advancement for sustainable development and growth of any nation is not in doubt. Knowledge of mathematics is a fundamental tool in the study of science and related courses. However, poor academic achievement of students who sat for West Africa Examination Council (WAEC) examination in mathematics between 2019 and 2024, the failure could be attributed in part to the teaching strategy adopted by teachers in teaching the subject matter. Hence, to improve students' academic achievement in mathematics, it is expected of the teachers to adopt innovative strategies which may have the capacity to spur students' interest as well as keep them motivated enough to stick with the learning process in teaching the subject matter. This study therefore sought to find out the effect of Mathematics Gamification Instructional Package on the achievement of senior secondary school students in Mathematics in Kontagora, Niger State.

Purpose of the Study

The aim of this research is to investigate the effect of Mathematics Gamification Instructional Package on the achievement of senior secondary school students in Mathematics in Kontagora, Niger State. The specific objectives are to:

1 Examine the difference in achievement scores of students taught mathematics using Mathematics Gamification Instructional Package and those taught with Conventional method?

2 Find out the difference in the mean achievement scores of male and female students taught Mathematics using Mathematics Gamification Instructional Package?

Research Questions

The following research questions were raised to guide the study:

1. What is the mean difference in achievement scores of students taught mathematics using Mathematics Gamification Instructional Package and those taught with Conventional method?
2. Will there be any difference in the mean achievement scores of male and female students taught Mathematics using Mathematics Gamification Instructional Package?

Research Hypotheses

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

H_{01}: There is no significant difference in the mean achievement scores of students taught mathematics using Mathematics Gamification Instructional Package and those taught with Conventional method.

H_{02}: There is no significant difference in the mean achievement scores of male and female students taught Mathematics using Mathematics Gamification Instructional Package.

Methodology

The research adopted the pre-test post-test randomized experimental research design. The target population was 5287 senior secondary school SS II mathematics students. 87 SSII was used as the sample size for the study. The study employed simple random sampling techniques to select two (2) schools of intact classes for the main study. The classes were assigned to experimental group one and one control group using random sample technique. Mathematics Gamification was used as mode of instruction for experimental group while the conventional method was used for the control group. The instruments used for the study named Trigonometry Achievement Test (TRAT), that was adopted from the previous WAEC past questions, that comprised of 25 multiple choice objective questions on the Trigonometry concepts. Trigonometry Achievement Test (TRAT) was validated by experts in Mathematics. A senior lecturer in Mathematics Department, Federal University of Education, Kontagora, and Mathematics teachers with Masters' degree from senior secondary schools in Kontagora. To determine the reliability of TRAT, a pilot test was conducted in a school within the population of the study, but outside the schools sampled for the study. In this study, one school was selected for the pilot test with thirty (30) SSII students randomly selected. A reliability test was carried out using test-retest method and Pearson Moment Correlation Coefficient was used to obtain the reliability coefficient of 0.76 on research instrument. Both experimental and control groups were given Pretest before the treatment that lasted for weeks. After the treatment, posttest was administered immediately on the groups. Experimental procedure: Experimental group was exposed to mathematics gamification instructional package while control group was exposed to Conventional teaching method. Mean and standard deviation were used to analyze research questions while t-test was used to analyze research hypotheses.

Results

Research Question one: What is the mean difference in achievement scores of students taught mathematics using Mathematics Gamification Instructional Package and those taught with Conventional method?

Table 1: Mean and Standard Deviation of Pretest and Posttest Scores of Experimental and Control Group (Mathematics Gamification Instructional Package and Conventional Method)

Group	N	Pretest		Posttest		Mean Gain
		X	SD	X	SD	
Conventional Method	49	35.27	14.26	47.43	4.86	12.16
Gamification	38	24.53	11.54	68.68	5.42	44.15

Table 1 shows the mean and standard deviation of the mean achievement scores of experimental group (Mathematics Gamification Instructional Package) and control group (Conventional method) in pretest and posttest. The result revealed that mean and standard deviation scores of the pretest and posttest experimental group are $\bar{X}$ =35.27, SD = 14.26 and $\bar{X}$ = 24.53, SD = 11.54 respectively. This gives a mean gain of 12.16 in favour of the posttest. On the other hand, the mean and standard deviation of the pretest and posttest of the control group are $\bar{X}$ = 24.53, SD = 11.54 and $\bar{X}$ =68.68, SD = 5.42 respectively and gives a mean score of 44.42 in favour of the posttest. The result also revealed that control group and experimental group had mean gain of 12.16 and 44.15 respectively, and with the experimental group having the highest mean gain of 44.15.

Research Question Two: Will there be any difference in the mean achievement scores of male and female students taught Mathematics using Mathematics Gamification Instructional Package?

Table 2: The mean and standard deviation of pretest and posttest scores of male and female on Mathematics Gamification Instructional Package

Group	N	Pretest		Posttest		Mean Gain
		$\bar{X}$	SD	$\bar{X}$	SD	
Male	14	21.71	7.31	69.57	4.16	47.86
Female	24	26.17	13.29	68.17	6.07	42.00

Table 2 shows the mean and standard deviation of the pretest and posttest scores of male and female experimental group. From the result, it can be seen that mean score of the pretest and posttest score of the male are $\bar{X}$ =21.71, SD = 7.31 and $\bar{X}$ = 69.57, SD =4.16. The mean gain is 47.86 in favour of the male posttest achievement score. Similarly, the mean and standard deviation of pretest and posttest score of female are $\bar{X}$ = 26.17, SD = 13.29 and $\bar{X}$ = 68.17, SD = 6.07, the mean gain is 42.00 in favour of the female posttest score. Also the result reveals the difference of 5.86 between the posttest mean gains score of male and female in favour of the male.

Hypothesis One: There is no significant difference in the mean achievement scores of students taught mathematics using Mathematics Gamification Instructional Package and those taught with Conventional method.

Table 3: t-test Analysis of mean achievement scores of Mathematics Gamification Instructional Package and Conventional Method on Senior Secondary School Mathematics students

Participants	N	$\bar{X}$	SD	t-cal	df	p-value
Conventional Method	48	35.27	14.26	1.72	85	0.00
Gamification	39	24.53	24.53			

0.05 level of significance

From the table. The results showed the mean score for male students is X=35.27 and the mean for female students X=24.53, t-cal of 1.72, df = 85, with p=0.00. Since $p<0.05$, Hypothesis one is hereby rejected. Therefore, there was significant difference in the mean achievement scores of students taught mathematics using Mathematics Gamification Instructional Package and those taught with Conventional method.

Hypothesis Two: There is no significant difference in the mean achievement scores of male and female students taught Mathematics using Mathematics Gamification Instructional Package.

Table 4: t-test Analysis of mean scores of Mathematics Gamification Instructional Package on academics achievement of male and female Senior Secondary School mathematics students

Participants	N	$\bar{X}$	SD	t-cal	Df	p-value
Male	14	69.57	4.16	.765	36	0.42
Female	24	68.17	6.07			

0.05 level of significance

From the table, the results showed the mean score for male students is X=69.57 and the mean for female students is X=68.17, t-cal of 0.765, df = 36, with p = 0.42. Since $p>0.05$, Hypothesis two is hereby not rejected. Therefore, there was no significant difference in the mean achievement scores of male and female students taught Mathematics using Mathematics Gamification Instructional Package.

Discussion of findings

There was no significant difference in the mean achievement scores of students taught mathematics using Mathematics Gamification Instructional Package and those taught with Conventional method. This is in support of the work of Nwachukwu & Johnson (2020) which reported that students' gamified teaching method (GTM) significantly improved students' academic performance. It is also concur with Jimoh *et al* (2022) who reported that there was significant difference in the mean achievement scores of students taught mathematics using Google hangouts, Zoom Application and Conventional Method.

There was no significant difference in the mean achievement scores of male and female students taught Mathematics using Mathematics Gamification Instructional Package. This is in support of the findings of Ilobeneke *et al* (2018) who revealed that there was no significant difference exist between gender level when both were taught using Facebook instructional platform ($p>0.05$ level of significant) ($p=0.179$).

Conclusion

Implementing Mathematics Gamification Instructional Package could perhaps enhance students' achievement positively at senior secondary school mathematics level. Mathematics Gamification Instructional Package is not gender bias based on students' achievement as it gives equal learning opportunities to both the male and female students in learning mathematics.

Recommendation

It is recommended that senior secondary schools mathematics students should adopt Mathematics Gamification Instruction Package in teaching and learning of mathematics, since it improves students' academic achievement and gender friendly.

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TEACHERS' ATTITUDES TOWARDS ENTREPRENEURIAL APPROACHES TO EDUCATIONAL TECHNOLOGY INTEGRATION IN ILORIN METROPOLIS

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Abstract

This study investigates teachers' attitudes toward entrepreneurial approaches to educational technology (EdTech) integration in Ilorin Metropolis, Nigeria. Using a descriptive survey design, data were collected from 200 teachers across nine public and private secondary schools via a validated questionnaire (TATEATEQ). Findings reveal moderate awareness (M = 2.85) of entrepreneurial strategies like lean startup and design thinking, with design thinking perceived as more relevant (M = 3.80). Access to training and leadership support significantly influences attitudes, while infrastructural barriers persist, particularly in public schools. Private school teachers have a higher mean score of attitudes (M = 3.80) than their public counterparts (M = 3.30). Recommendations include improving professional development and infrastructure to provide equitable adoption of EdTech.

Keywords: **Entrepreneurial Approaches, Educational Technology (EdTech), Teacher Attitudes, Lean Startup Methodology, Design Thinking**

Introduction

EdTech has become a transformational tool through which educational technology enhances instructional delivery, learning experiences, and outcomes for students in what is considered the digital age. It has a promise for better access to education, personalized learning pathways, and new 21st-century teaching methodologies throughout the world and even in Nigeria, where several promising gains have developed in Ilorin Metropolis. All these are raising critical questions on the digitization of classrooms and their integration into pedagogy: What kind of technology is introduced? How effective is the application? This transformation can be largely attributed to entrepreneurial approaches-'innovative, agile, and risk-embracing strategies that promote sustainable and user-centered integration of EdTech into educational systems.

However, its effective integration still remains a major challenge as EdTech promises more accessibility and better outcomes. It does not only concern the tools but also the strategies that will direct their use. Entrepreneurial thinking opportunity recognition, innovation, and risk tolerance gives one an important understanding and frame that defines the approach to these types of problems (Weidlich et al., 2025; Mohsen et al., 2025). In contrast to the definitions above, such approaches emphasize adaptability and user-centered design that provide themselves as viable models for meaningfully embedding technology in teaching and learning.

One significant kind of entrepreneurial thinking is the application of lean startup-type methodologies. This allows EdTech developers to operate according to highly agile startup principles in rapid prototyping and iterative feedback relying on Minimum Viable Products

(MVPs). Developing tiny, testable versions of products for real-world feedback is prioritized by lean methodologies instead of committing huge resources to solutions that, at the end, might render useless. The EdTech tools, therefore, become matched to the actual needs of the educators and students involved. It is noted by Uzun et al. (2025) that this model not only speeds up innovation but also builds relevance and sustainability for educational environments.

Some key practices include designing the MVPs to solve some educational challenges, testing directly with users, and developing the product in light of actual experiences (Ries, 2020). Supplementary to this is design thinking, which is mainly around empathy/user experience. Thus in EdTech, much of design thinking involves enabling users to have an experience by interviewing them and observing them, building prototypes under pedagogical principles, ensuring that tools can fold into classroom workflows themselves, all of which make sure that "technology is not for technology". Such processes help to avoid making sure that tools serve genuine educational objectives. Teacher-students and administrators will play a vital role in co-designing of the tools to enhance their usability and instructional relevance (Dam & Siang, 2023).

Entrepreneurial success in EdTech must also have business models that will facilitate its scalability. Freemium models, partnerships at the level of districts, and collaborative sales strategies are among these kinds of models (Mohsen et al., 2025). A combination of a balancing act on monetization with mission-oriented branding, which builds credibility and loyalty in the users, sets the example of most successful EdTech products. Such are user-defined and scalable operations, in that they usually rely on a focused design, strong user orientation, and scalability.

The fate of these entrepreneurial approaches will always rely on teachers. They are never just users but instead are co-creators and sometimes gatekeepers to advances in school. The extent to which such vision is understood can determine, really, how far such lean and design thinking strategies will go in successful implementation outcomes. Several factors can also shape such attitudes, including school ownership, infrastructure, training, and leadership support (Ranzato et al., 2025). In the context of Ilorin Metropolis, where educational development occurs despite disparities in infrastructural growth and other materials resources, teacher readiness for entrepreneurial EdTech strategies needs to be understood. Such insights then help to frame more effective, inclusive, and context-sensitivity implementation models for educational innovation in Nigeria.

This study, therefore, investigates teachers’ attitudes toward entrepreneurial approaches to educational technology integration in Ilorin Metropolis. It seeks to uncover the level of awareness, perceptions of strategy relevance, factors influencing attitudes, and variations based on school ownership, drawing attention to teachers’ pivotal role in shaping the future of EdTech in Nigeria.

Research Questions

Four research questions were raised and answered in the study:

1. What is the level of awareness among teachers in Ilorin Metropolis regarding entrepreneurial approaches to educational technology integration?
2. How do teachers in Ilorin Metropolis perceive the relevance of lean startup and design thinking strategies in EdTech implementation?
3. What factors influence teachers’ attitudes towards adopting entrepreneurial approaches in integrating educational technology?
4. Are there significant differences in teachers’ attitudes based on school ownership?

Research Hypotheses

Three research hypotheses were tested at 0.05 level of significance in this study:

H_{01}: There is no significant relationship between teachers' attitudes toward educational technology integration in Ilorin Metropolis.

H_{02}: There is no significant difference in teachers' attitudes toward entrepreneurial approaches to EdTech integration based on gender.

H_{03}: Teachers' years of experience do not significantly influence their attitudes toward entrepreneurial approaches in educational technology integration.

Methodology

This study employed a descriptive survey design to examine teachers' attitudes toward entrepreneurial approaches to educational technology (EdTech) integration in Ilorin Metropolis. The design was chosen because it allows for the collection of data from a representative sample to describe current patterns, perceptions, and influencing factors without manipulating any variables. The population for the study comprised all teachers in the 468 public and private secondary schools across Kwara State, with a focus on 9 secondary schools located within Ilorin Metropolis. These areas represent the most urbanized and technologically active educational settings in the state. A stratified random sampling technique was employed with a total of 200 teachers were selected from both public and private schools to ensure balanced representation across school types. Sampling was based on Krejcie and Morgan's sample size determination method.

Data were collected using a structured instrument titled the Teachers' Attitudes Towards Entrepreneurial Approaches to Educational Technology Integration Questionnaire (TATEATEQ). The questionnaire had five sections: demographic information; awareness of entrepreneurial strategies; degree of relevance of the lean startup and design thinking; attitude toward EdTech integration; influencing factors or barriers. Items were rated on a 5-point Likert scale ranging from Strongly Disagree to Strongly Agree.

The instrument was duly validated by three experts in Educational Technology from Ilorin University, and, with a pilot study involving 30 teachers outside the sample, a Cronbach's alpha reliability coefficient was yielding (Unknown yet), indicating high internal consistency. Data collection was conducted in person with the support of trained assistants. Teachers were briefed on the study's purpose and assured of the confidentiality of their responses. Collected data were analyzed using SPSS version 23.0 for the purpose of responding to research questions using descriptive statistics (mean and standard deviation) and to test the hypotheses using Pearson correlation, t-tests, and ANOVA at a significance level of 0.05. Ethical approval was granted by the relevant authorities whereby participants preceded to give their voluntary consent to take part in the study.

Results:

Analysis covered the data that were collected from 200 teachers in Ilorin Metropolis, using the SPSS version 23.0. Descriptive statistics (mean and standard deviation) were used to respond to the four research questions, whereas three hypotheses were tested by Pearson correlation, independent t-tests, and one-way ANOVA. The results are reported below under two subheadings: Analysis of Research Questions and Testing of Hypotheses.

Analysis of Research Questions

Research Question 1: What is the level of awareness among teachers in Ilorin Metropolis regarding entrepreneurial approaches to educational technology integration?

A 5-point Likert scale was used to measure awareness (1 = Very Low, 5 = Very High) on items related to lean start-up method, design thinking, and other entrepreneurial strategies. Mean awareness score was 2.85 (SD = 0.92), reflecting a moderate level of awareness of the teachers. Ninety-one percent of the teachers said that they had low to very low level of awareness (scores 1-2). That's what it means: a score of 35 percent means a medium level of awareness (score 3), whereas 20 percent is designated high to very high awareness (scores 4-5). Awareness was somewhat high for design thinking (M = 3.10, SD = 0.87) compared to lean start-up methodology (M=2.60, SD=0.95), and this shows that teachers understand user-centered design principles more than development approaches in agile.

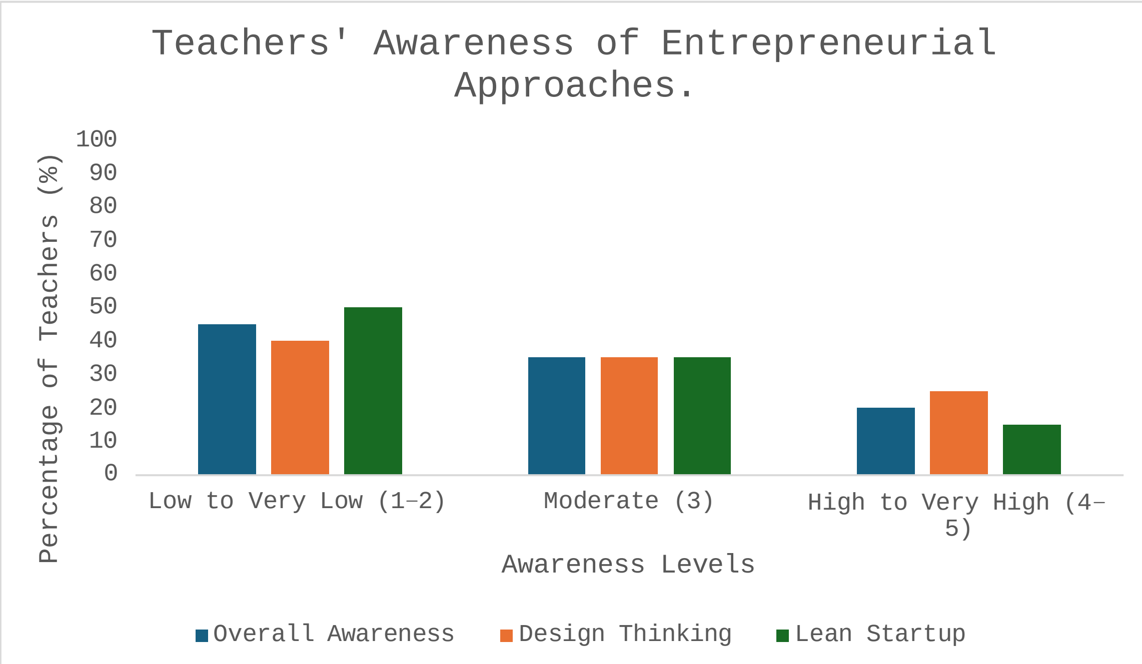

***Figure 1**: Percentage distribution of teachers' awareness levels for entrepreneurial approaches, including overall awareness, design thinking, and lean startup methodology.*

Research Question 2: How do teachers in Ilorin Metropolis perceive the relevance of lean startup and design thinking strategies in EdTech implementation?

Teachers' views on the significance of lean startup and design thinking techniques were rated on a 5-point Likert scale (1 = Not Relevant; 5 = Highly Relevant). The mean score of perceived relevance for the whole population was 3.65 (SD = 0.78), implying a generally positive perception. It was perceived that design thinking was more relevant (M = 3.80, SD = 0.75) compared to lean startup methodology (M = 3.50, SD = 0.80). About 60 % of respondents rated these strategies as relevant or very relevant (4-5). Private school teachers (M = 3.90, SD = 0.70) perceived more relevance than public school teachers (M = 3.40, SD = 0.82).

Research Question 3: What factors influence teachers' attitudes towards adopting entrepreneurial approaches in integrating educational technology?

The influences on teachers' attitudes were assessed with relevant items regarding infrastructure, training, leadership support, and personal beliefs about EdTech. It was found that the most potent among the influences were access to training (M = 4.10, SD = 0.65), considered as strong influence by 75% of the respondents, and leadership support (M = 3.95, SD = 0.70), which has been acknowledged by 68% of teachers. The availability of infrastructure (M = 3.60, SD = 0.85) and personal belief in the worth of EdTech (M = 3.50, SD = 0.90) were also important but to a lesser extent. Limited access to reliable internet and devices was frequently cited as barriers, with public schools being most affected (M = 3.20, SD = 0.95).

Research Question 4: Are there significant differences in teachers' attitudes based on school ownership?

Teacher attitudes regarding entrepreneurial approaches were measured with a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) and compared between public and private school teachers. The general mean attitude score was 3.55 (SDs = 0.80). Private school teachers had more favorable attitudes (M = 3.80, SD = 0.72) than did their public school counterparts (M = 3.30. SD = 0.85). An independent t-test found significant differences between the attitudes regarding school ownership ($t(198) = 4.32$; $p = 0.001$), with private school teachers much more open to entrepreneurial EdTech strategies.

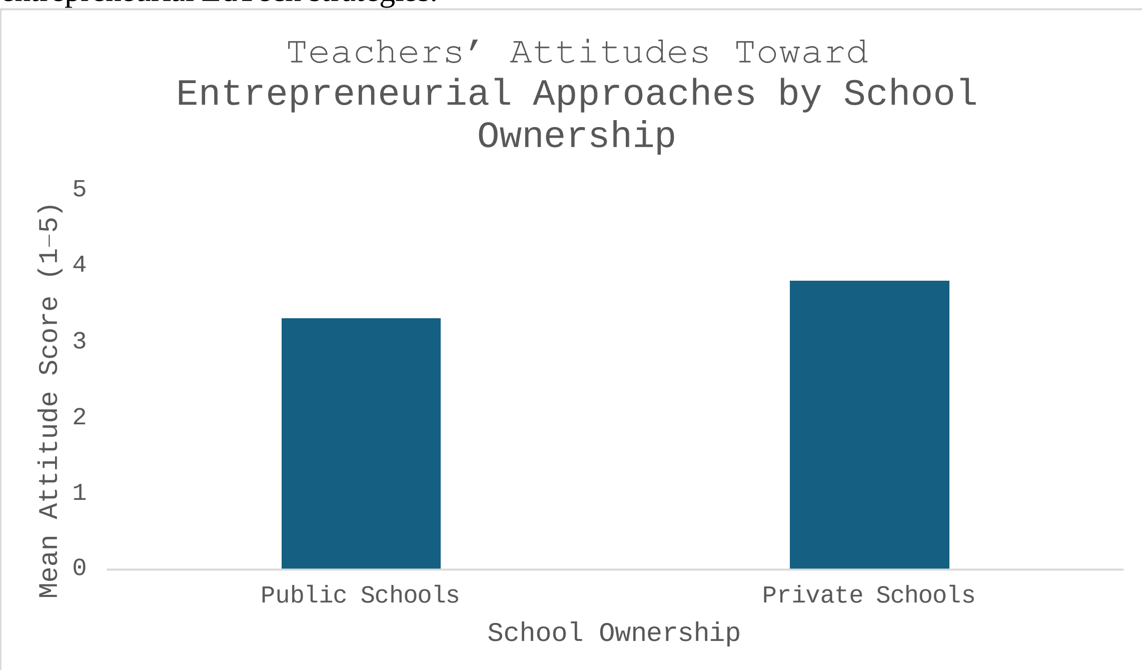

Figure 2: *Comparison of mean attitude scores toward entrepreneurial approaches between public and private school teachers.*

Testing of Hypotheses

Hypothesis One:

H_{01}: There is no significant relationship between teachers' attitudes toward educational technology integration in Ilorin Metropolis.

A Pearson correlation analysis was conducted to explore the relationship between teachers' attitudes toward entrepreneurial approaches and their general attitude toward EdTech integration. Interestingly enough, a significant positive correlation ($r = 0.62$, $p < 0.001$) implied that teachers with a more positive attitude toward EdTech integration were also more inclined to foster positive attitudes toward entrepreneurial approaches. Therefore, we accept the alternative hypothesis (H_1) and reject the null hypothesis (H_{01}).

Table 1: Correlation between Attitudes toward EdTech and Entrepreneurial Approaches (Hypothesis H_{01})

This table presents the Pearson correlation results testing the relationship between teachers' attitudes toward general EdTech integration and entrepreneurial approaches.

Variable Pair	Pearson Correlation (r)	p-value	Result
Attitudes toward EdTech vs. Entrepreneurial Approaches	0.62	<0.001	H_{01} Rejected

Table 1: Pearson correlation showing a significant positive relationship between teachers' attitudes toward EdTech integration and entrepreneurial approaches ($r = 0.62$, $p < 0.001$).

Hypothesis Two:

H_{02}: There is no significant difference in teachers' attitudes toward entrepreneurial approaches to EdTech integration based on gender.

An independent t-test was used to compare attitudes between male ($n = 110$, $M = 3.50$, $SD = 0.82$) and female ($n = 90$, $M = 3.60$, $SD = 0.78$) teachers: No significant differences were found in this test ($t(198) = 0.87$, $p = 0.386$), indicating that gender had no bearing on teachers' attitudes toward entrepreneurial approaches; therefore, the null hypothesis (H_{02}) was accepted.

Table 2: Differences in Attitudes by Gender (Hypothesis H_{02})

This table summarizes the t-test results comparing teachers' attitudes toward entrepreneurial approaches by gender.

Group	Sample Size (n)	Mean (M)	Standard Deviation (SD)	t-value	p-value	Result
Male	110	3.50	0.82	0.87	0.386	H_{02} Not Rejected
Female	90	3.60	0.78	-	-	-

Table 2: *Independent t-test results showing no significant difference in teachers' attitudes by gender ($t(198) = 0.87$, $p = 0.386$).*

Hypothesis Three:

H_{03}: Teachers' years of experience do not significantly influence their attitudes toward entrepreneurial approaches in educational technology integration.

One-way ANOVA was conducted in order to perceive whether experience affected the attitudes towards teaching. Three categories were used in grading experience that included 0-5 years, 6-10 years, and 10-15 years. On applying ANOVA, there was no significance yield ($F(2, 197) = 1.45$, $p = 0.237$). Thus, there was no difference in mean attitude scores over the years of experience 0-5(M=3.58, SD=0.80), 6-10 (M=3.52, SD=0.83), >10 (M=3.55, SD=0.79). Thus, there is no rejection of the null hypothesis H_{03}.

Table 3: Influence of Years of Experience on Attitudes (Hypothesis H_{03})
This table presents the ANOVA results examining the influence of teachers' years of experience on their attitudes toward entrepreneurial approaches.

Experience Category	Mean (M)	Standard Deviation (SD)	F-value	p-value	Result
0–5 Years	3.58	0.80	1.45	0.237	Not Rejected
6–10 Years	3.52	0.83	-	-	-
>10 Years	3.55	0.79	-	-	-

***Table 3**: One-way ANOVA results showing no significant influence of years of experience on teachers' attitudes (F(2, 197) = 1.45, p = 0.237).*

Discussion of Findings:

The findings of this study provide valuable insights into teachers' attitudes toward entrepreneurial approaches to educational technology (EdTech) integration in Ilorin Metropolis, aligning with the research questions and hypotheses.

Research Question 1: Level of Awareness of Entrepreneurial Approaches

The knowledge of teachers of Ilorin Metropolis about entrepreneurial strategies namely design thinking and lean startup was moderate (M = 2.85, SD = 0.92). Awareness of design thinking (M = 3.10) to some extent reached this level on account of its pedagogical relevance. In contrast, lean startup (M = 2.60) is less familiar. Mohsen et al. (2025) also found that there was limited exposure to agile EdTech strategies in resource-constrained settings. This finding indicates the need for need-based professional development opportunities to strengthen teachers' understanding of entrepreneurial frameworks, especially in public schools where access and awareness are still limited.

Research Question 2: Perceived Relevance of Lean Startup and Design Thinking

Teachers have a positive perception of lean startup and design-thinking strategies (M = 3.65, SD = 0.78), with design thinking rated higher (M = 3.80) owing to its emphasis on empathy and user needs. Private school teachers (M = 3.90) thus find these strategies more relevant than their public school counterparts (M = 3.40), most likely due to their better access to technology and training (Ranzato et al., 2025). Indeed, this is what Weidlich et al. (2025) argue: that when resources are abundant, confidence in the adoption of innovation is augmented. The promotion of practical benefits may enhance adoption further, particularly within the context of under-resourced public schools.

Research Question 3: Factors Influencing Teachers' Attitudes

Access to training (M=4.10) and leadership support (M=3.95) were mainly seen as the drivers affecting the teachers' attitudes toward entrepreneurial EdTech approaches. This view is supported by Heikkinen et al. (2025) regarding the relevance of professional development and administrative support. Infrastructure (M=3.60) and personal beliefs (M=3.50) were lesser factors involved, particularly in public subjective settings (M=3.20), which were already grappling with internet and technological device necessities. These challenges are echoed by Bond et al. (2024), who highlighted equity and infrastructure gaps as the main obstacles. Strategic investments and training are the keys to resolving these EdTech adoption concerns.

Research Question 4: Differences in Attitudes based on School Ownership

This evidence of distinct attitudes of statistic private ($M = 3.80$) and public teachers ($M = 3.30$) regarding entrepreneurial approaches to underlining the impact of school ownership upon EdTech integration. Thus, the better disposition of private teachers could be associated with better resources, leadership that comprehensively backs its teachers, and exposure to cutting-edge practices, according to the appraisal by Ranzato et al. (2025). The gap thus identified requires measures in the public schools, in the nature of policy intervention that can start to address the problems facing EdTech integration at those levels, such as infrastructural improvement and teacher capacity development (Bond et al., 2024).

Hypotheses Testing

The rejection of H_{01} ($r = 0.62$, $p < 0.001$) shows a strong positive correlation between teachers' attitudes toward general EdTech use and entrepreneurial approaches, supporting Holmes et al. (2019). However, H_{02} was not rejected ($t(198) = 0.87$, $p = 0.386$), indicating no significant gender influence, consistent with Regan and Jesse (2019). Similarly, H_{03} was not rejected ($F(2, 197) = 1.45$, $p = 0.237$), suggesting years of experience do not significantly impact attitudes, likely due to the novelty of entrepreneurial strategies across all experience levels (Mohsen et al., 2025).

Implications

The findings highlights that interventions must be tailored to enhance teachers' awareness of and adoption of entrepreneurial EdTech strategies. Given the sharp contrast between public and private schools and the relative lack of awareness among public school educators regarding EdTech solutions, professional development in design thinking and lean startup methods should be prioritized. Policies that provide equitable access to infrastructure and training are key to decreasing the gulf between public and private schools. Also, establishing communities of practice, as suggested by Bond et al. (2024), would enhance collaboration and sharing of knowledge among teachers, thereby promoting more entrepreneurial approaches.

Conclusion

This study investigated teachers' attitudes toward entrepreneurial approaches to EdTech integration in Ilorin Metropolis. Findings showed a moderate level of awareness, positive relevance perceptions, and considerable influences deriving from training and leadership support. The results showed some significant differences in attitudes held by private and public sector teachers: private school teachers appeared to be much more willing to engage with new approaches and strategies, such as lean startup methodology and design thinking, likely due to better resources and support mechanisms available to them (Bond et al., 2024). The strong association between EdTech attitudes in general and entrepreneurial approaches suggests that they may actually be viable alternatives for improved integration when teachers are supported appropriately (Holmes et al., 2019). In other words, infrastructural bottlenecks coupled with low levels of awareness, particularly seen in public schools, clearly point to the need for such targeted interventions (Mohsen et al., 2025). Any moves to encourage professional development, improve infrastructure, and enhance equitable access should help drive the uptake of these entrepreneurial EdTech strategies for the wider integration of usable tools in Ilorin Metropolis and other similar settings.

Recommendations

Deriving from this study on teachers' attitudes toward entrepreneurial EdTech approaches in the Ilorin Metropolis, the recommendations below would go a long way in making such approaches more aware not just to make them aware but also to adopt and implement them:

1. Enhance Professional Development: Education authorities should continue training teachers in the lean startup and design thinking techniques for a medium awareness level (M = 2.85) but ensure there is certainly practical application in the classroom. Train both public and private school teachers as there is a gap between them (Mohsen et al., 2025).
2. Improve Infrastructure: There is also a need for sufficient internet connectivity and modern devices for public schools, as revealed from the authority ratings concerned with EdTech usage adoption:- moderate (M = 3.20). Such targeted investments will improve teachers attitudes and capacity for adoption of EdTech (Bond et al., 2024).
3. Strengthen Leadership Support: Since leadership support is rated high (M = 3.95), school administrators should provide resources, give clear guidance, and lead a culture that embraces innovation (Heikkinen et al., 2025).
4. Promote Equity in Resource Allocation: The gaps between private (M = 3.80) and public school teachers (M = 3.30) should be bridged through fair financing concerning training and access to tools under the public-private partnerships (Ranzato et al., 2025).
5. Foster Communities of Practice: Establishing networks of teachers will help promote sharing of ideas and collaboration among members as well as core best practices regarding entrepreneurial EdTech integration (Bond et al., 2024).
6. Integrate into Teacher Education: Such entrepreneurial EdTech strategies should be incorporated into training by institutions such as University of Ilorin in order to prepare future teachers (Uzun et al., 2025).
7. Encourage Stakeholder Collaboration: Together with teachers, co-designing the EdTech solutions would make them more appropriate and useful in a user's sense of reality as determined in design thinking (Dam & Siang, 2023).

These progressive measures will empower EdTech adoption and discourage any chance of facilitating it in the innovative Ilorin educational framework.

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SENIOR SECONDARY SCHOOL TEACHERS' PERCEPTION ON THE INTEGRATION OF VIRTUAL REALITY FOR TEACHING BIOLOGY CONCEPTS IN KWARA STATE, NIGERIA

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Abstract

Virtual reality is a computer-generated, three-dimensional environment that allows users to enter and experience a digital environment in real-time so that it feels as if they are in that environment. It was observed that concepts such as photosynthesis, respiration, enzyme activity, sex-linkages, genes, nervous system, hormones, Mendelian genetics, and nutrient cycling in nature, among others, are perceived as difficult by teachers and students in senior secondary school. The study investigated senior secondary school teachers' perception on the integration of virtual reality for teaching Biology concepts in Kwara State. Specifically, the study: (i) examined Biology teachers perceived usefulness of virtual reality for teaching; (ii) determined Biology teachers perceived ease of use of virtual reality for teaching; (iii) examined the influence of gender on Biology teachers perceived usefulness of virtual reality for teaching and (iv) examined the influence of gender on Biology teachers perceived ease of use of virtual reality for teaching. The population for this study comprised all senior secondary Biology teachers in Kwara State. Purposively, 263 Senior Secondary Biology teachers in Ilorin metropolis were sampled. The data was analysed based on the stated research questions and hypotheses, using frequency count, mean, and t-test. The result showed that: Teachers perceived the usefulness of virtual reality for teaching Biology with a mean score 2.92; Teachers perceive the ease of use of virtual reality for teaching Biology with a mean score 3.10; there was a significant difference between male and female undergraduate perceived usefulness of online learning (.069 < 0.05); and there was no significant difference between male and female Biology teachers in perceived ease of use of virtual for teaching biology concepts (.513 > 0.05). The study concluded that the perception of Biology teachers on virtual reality for teaching Biology concepts is good. Based on the findings of the study, the study recommends that Biology teachers should endeavour to improve the use of virtual reality for teaching difficult biology concepts.

Introduction

Education is divided into two categories: teaching and learning. Teaching is the process of transmitting knowledge from a teacher to a student. Ibironke et al (2018) stated that education is a lifelong process that involves the facilitation and acquisition of knowledge from teachers to learners. There are several fields of study in education, one of which is science. Science is a field of knowledge, such as Physics, Biology, Chemistry, among others, that has been instrumental to the development of nations. Biology is one of the popular subjects out of the three natural science disciplines at secondary schools in Nigeria; the other ones are Chemistry and Physics (Jibril et al., 2015). Biology as a natural science subject is made up of disciplines, such as anatomy, botany, physiology, biochemistry, ecology and zoology (Ahmed & Lawal, 2020).
Biology is a prerequisite to study courses like medicine, nursing, pharmacology, biochemistry, agriculture, among others (Ihejiamaizu & Ochui, 2016). Knowledge of Biology plays an important role in the lives of every individual and has an increasing prominence in life. The study of Biology improves all aspects of life on earth and helps us to understand ourselves and other organisms around us (Ahmed & Lawal, 2020). In Nigeria, the objectives of the Biology curriculum are to prepare students to acquire adequate laboratory and field skills in Biology, meaningful and relevant knowledge of Biology, the ability to apply scientific knowledge to everyday life, community health, agriculture, and a reasonable and functional scientific attitude (Federal Ministry of Education, 2009). Edache et al. (2019) noted that the most difficult concepts in biology include Mendelian genetics, protein synthesis, cell division (mitosis and meiosis), genes and chromosomes, skeletal system, cellular respiration, the Calvin cycle and evolution. Ogunkunle and Onwunedo (2017) asserted that what constitutes a good teaching and learning of Biology is the use of

appropriate alternative means of imparting knowledge to ensure that all important concepts are passed on to the learner.
Teaching Biology can be supported with technology tools. Educators are fast realising that the use of computer-assisted for teaching and learning is essential (Ebrahimi, 2016). The advancements in mobile and image-processing technologies have enabled students to access learning resources and receive instruction in virtual world contexts (Hwang et al., 2017). One of the advancements of technology in education, where students can receive learning in a virtual world context, is virtual reality. Virtual reality is a computer-simulated, game-based learning environment which appears real and gives learners the opportunity to interact with the learning materials and share learning experiences with teachers and other learners (Onele, 2020).

Virtual reality is a computer-generated, three-dimensional, multimedia environment. In virtual reality, participants can engage and manipulate simulated physical elements in the environment and interact with fictional or simulated components (Onele, 2020). A virtual reality is also known as immersive visualisation, which is a 3D interpretation environment. A 3D interpretation environment is an artificial virtual environment produced by computers. Virtual reality allows users to enter and experience a digital environment in real-time so that it will feel as if they are in that environment (Astuti et al., 2019). VR allows learners to acquire knowledge and skills outside the four walls of the classroom without really feeling the gap of not being in the conventional classroom system (Soetan et al., 2020). VR is an important technology tool which can be used in different levels of education to assist students in learning and building knowledge in innovative and more attractive ways (Astuti et al., 2019).

Studies have shown that virtual reality technology can be used for teaching. A study was conducted by Akgün and Atici (2022). The study found that immersive virtual reality environments had a positive, moderate effect on students' academic performance. Virtual reality can be used by the teacher to teach Biology in the classroom as a teaching material. Teaching resources are essential in education and should be used in the teaching process to ensure that the teaching process is effective. The use of suitable teaching material will effectively increase the students’ interest in learning (Yusof et al., 2020). Therefore, integration of innovative technology tools like virtual reality into the teaching process might solve difficult concepts in Biology. Good teachers are constantly introducing new methods and technologies that will make teaching easier and learning meaningful to the students (Soetan et al., 2020).
Teachers are essential in integrating virtual reality into teaching. In order to assure future utilisation of VR, teachers’ perception toward integrating VR as an educational tool for teaching the Biology concept is imperative. A key determinant of the success of any educational initiative is the teacher (Junaidu, 2019). It is essential to know the teachers’ perception of the integration of virtual reality for teaching Biology concepts. Teachers are key players in integrating virtual reality into the classrooms. Perception is the way or which humans perceive something, which includes human senses, human experiences, and human reactions to the environment (Putra et al., 2020). Perception is a feeling taken after experience through the interpretation of a stimulus recorded in the brain by more than one sense organ (Ajijola et al., 2021). From the above, perception can therefore be the way humans understand the knowledge and represent it from their point of view. Putra et al (2020) investigated the English teachers related to perception towards virtual reality as a learning media in Singaraja. The result showed that the teachers' perception of virtual reality in general was very positive. Wells and Miller (2020) examined teachers’ opinions about virtual reality technology in school-based agricultural education. Results indicated the teachers generally held favourable opinions about VR technology, intertwined with a considerable degree of uncertainty about the technology and its uses.

One variable that can influence teachers’ perception of teachers towards integration of technology for teaching is gender. The term gender refers to a wide range of biological, behavioural, physical and mental characteristics regarding differences between the female and the male population (Adigun et al. 2015). Anaza (2017) noted that gender differences in the use of technology should be carefully examined, rather than merely demonstrating differences. The influence of gender in classroom utilisation of technology also plays a major role in the selection, development and performance of instructional objectives (Soetan et al., 2020). Emeka (2015) study found that there was no effect of gender on lecturers' perception of the utilisation of modern technology. Abdullahi (2020) deduced that gender does not influence the adoption of virtual laboratories for teaching among physics teachers. Soetan et al (2020) study established that there was no significant difference between male and female teachers' awareness of virtual reality for instructional purposes.

The integration of virtual reality for teaching might address the issues of difficult concepts in Biology. It was observed in the studies of Etobro and Fabinu (2017); Chukwuemeka and Dorgu (2019); and Haruna, (2021) that photosynthesis, respiration, enzyme activity, dominance and codominance, sex-linkages, genes and chromosomes, mitosis and meiosis, nervous system, hormones, Mendelian genetics, nutrient cycling in nature, ecological management, conservation of natural resources, pests, diseases of crops and reproductive system in plants are concepts in Biology that are perceived as difficult by teachers and students in senior secondary school. Also, these concepts are regarded as being at an abstract level in biology in the curriculum. As a result, students will lack the required knowledge and skills in learning Biology.

Also, it was observed that teachers used pictures to teach some of these concepts. However, pictorial representation is inadequate for teaching on topics such as cells, blood circulation, hormones, genes, chromosomes, nervous system, mitosis, meiosis and others. Danso (2016) explained that the difficult topics in Biology were characterised by complex terms and vocabulary; the abstract nature of the topics, the broad nature of the topics; teachers not conducting practical laboratory work but teaching theoretically and a lack of teaching/learning resources, and teachers' failure to cite practical examples students can relate with.

Therefore, it is essential to have technology that can be used to teach those concepts. Sarioglu and Girgin (2020) carried out a study on the effect of using virtual reality in 6th-grade science courses, the cell topic on students' academic performance and attitudes towards the course. The results of this research revealed that virtual reality technology has a positive effect on students' academic performance. Despite several studies on virtual reality, no studies exist relating to Biology teachers' perceptions on the integration of virtual reality for teaching. Therefore, this study investigated senior secondary school teachers' perception on the integration of virtual reality for teaching Biology concepts in Kwara State.

Purpose of the Study

The main purpose of the study was to find out senior secondary school teachers' perception on the integration of virtual reality for teaching Biology concepts in Kwara State. Specifically, the study:

1. Examined teachers' perceived usefulness of virtual reality for teaching Biology.
2. Determined Biology teachers perceived the ease of use of virtual reality for teaching.
3. Examined the influence of gender on Biology teachers perceived usefulness of virtual reality for teaching.
4. Examined the influence of gender on Biology teachers perceived ease of use of virtual reality for teaching.

Research Questions

Based on the purposes raised above, the following research questions were raised and answered in this study.

1. What is the perceived usefulness of virtual reality for teaching Biology?
2. How do teachers perceive the ease of use of virtual reality for teaching Biology?

Research Hypotheses

The following null hypotheses were raised and tested in this study;

H_{01}: There is no significant difference in Biology teachers perceived usefulness of virtual reality for teaching Biology concepts based on gender

H_{02}: There is no significant difference between male and female Biology teachers in perceived ease of use of virtual reality for teaching biology concepts

Methodology

The study adopted a descriptive research design of a survey type. The population for this study comprised all senior secondary Biology teachers in Kwara State, and the target population were all Senior Secondary Biology teachers in Ilorin metropolis. Purposively, the study sampled Biology teachers in Ilorin. 263 Senior Secondary Biology teachers were sampled in this study. Purposive sampling was used because only senior secondary schools that have ICT facilities were considered for this study. A researcher-designed questionnaire titled "Senior Secondary School Teachers' Perception on the Integration of Virtual Reality for Teaching Biology Concepts in Kwara State" was used to elicit information from the respondents on the integration of virtual reality for teaching Biology Concepts. The instrument was validated by three Educational Technology experts to determine the face and content validity of the instrument being used for this study. In order to determine the internal consistency of the questionnaire, the instrument was pilot-tested on Biology teachers in another local government, which is not part of the study sample. The internal consistency reliability method was used in getting responses from the pilot sample. The data obtained in the reliability test was subjected to Cronbach to determine the internal consistency of the questionnaire. The result yielded a 0.88 coefficient of reliability. The researcher proceeded to the secondary schools with an introductory letter and solicited permission from all appropriate authorities of the sampled schools. The researcher personally administered the questionnaire to the Biology teachers in the sample secondary schools with the help of a research assistant. During the process of this research, ethical issues were considered, and the respondents were permitted to participate in the study voluntarily without being coerced. Information gathered during this study was handled with utmost confidentiality so that when reporting the findings of the participants' identities would not be disclosed. The researcher ensured that all cited works are referenced and acknowledged to avoid plagiarism. The data was analysed based on the stated research questions and hypotheses, using frequency count, mean, and an independent sample t-test.

Results

Table 1: What is the teachers' perceived usefulness of virtual reality for teaching Biology?

Items	Mean
1. Using virtual reality in teaching Biology would enable me to break the barrier of abstract concepts	3.31
2. Using virtual reality would improve my teaching performance	3.15
3. As a teacher, using virtual reality for instruction would increase my productivity	3.22
4. Using virtual reality would enhance my teaching	3.04
5. Using virtual reality would make it easier to teach abstract concepts in Biology	3.18
6. I feel that using virtual reality for teaching will be beneficial to my teaching experience	2.51
7. I am comfortable using a virtual reality tool for teaching Biology in the classroom.	2.64
8. Virtual reality is very useful for displaying video content	2.86
9. Virtual reality is very effective for teaching Biology	2.63
10. Through virtual reality, students focus their senses on the teaching topic	2.75
Grand mean	**2.92**

To examine how teachers perceived the usefulness of virtual reality for teaching Biology, as stated in research question 1, and as shown in Table 1. The mean score for each of the question items is listed in the last column of the table. The average mean score for each of the items is 2.50. The average mean score of 2.50 was calculated by adding up each value of the 4-point Likert scale and divided by 4 (Strongly Agree = 4, Agree = 3, Disagree = 2, and Strongly Disagree = 1. 4+3+2+1=10 divided by 4 = 2.50. Item 1 has the highest mean score of 3.31, which is greater than the average mean score (2.50), and item 6 has the lowest mean score of 2.51, which is also greater than the average mean score (2.50). The grand mean of the entire item is 2.92, which is greater than the 2.50 average mean score. This implies that Biology teachers perceived the usefulness of virtual reality for teaching Biology concepts.

Table 2: How do teachers perceive the ease of use of virtual reality for teaching Biology?

Items	Mean
1. I feel that virtual reality is not difficult to operate	3.22
2. I feel that using virtual reality would be easy for me	3.00
3. I find virtual reality tools flexible for interacting with	3.09
4. Learning to operate virtual reality was easy for me	3.31
5. I do not encounter any technical problems when using virtual reality	2.99
6. I can easily connect virtual reality to my phone	2.94
7. I feel comfortable using my smartphone with virtual reality	2.92
8. I find virtual reality flexible for interacting with	2.86
9. I am becoming an expert at using virtual reality	3.14
10. I am motivated to use virtual reality in the classroom with my students	3.24
Grand mean	**3.10**

To find out if Biology teachers perceive the ease of use of virtual reality for teaching, as stated in research question 2, and as shown in Table 2 above. The mean score for each of the question items is listed in the last column of the table. The average mean score for each of the items is 2.50. The average mean score of 2.50 was calculated by adding up each value of the 4-point Likert scale and divided by 4 (Strongly Agree = 4, Agree = 3, Disagree = 2, and Strongly Disagree = 1. 4+3+2+1=10 divided by 4 = 2.50. Item 10 has the highest mean score of 3.24, which is greater than the average mean score (2.50), and item 8 has the lowest mean score of 2.86, which is also greater than the average mean score (2.50). The grand mean of the entire item is 3.10, which is greater than the 2.50 average mean score. Therefore, it can be established that Biology teachers perceive the ease of use of virtual reality for teaching.

Hypothesis Testing

H_{O1}: There is no significant difference between male and female Biology teachers' perceived usefulness of virtual reality for teaching Biology concepts based on gender

Table 3: Independent Sample t-test showing significant difference between male and female Biology teachers' perceived usefulness of virtual reality for teaching Biology concepts.

Gender	N	X	SD	Df	T	Sig. (2-tailed)	Decision
1. Male	89	45.91	6.55	261	-1.826	.069	Rejected
2. Female	174	44.14	6.35				

From Table 3, it can be deduced that there was a significant difference between male and female Biology teachers' perceived usefulness of virtual reality for teaching Biology concepts based on gender. This is reflected in the result: t (261) = -1.826, $p < 0.05$. That is, the result of the t-value of -1.826, resulting in a 0.069 significance value, which is less than the 0.05 alpha value. Thus, the null hypothesis is rejected. This implies that there was a significant difference between male and female Biology teachers perceived usefulness of virtual reality for teaching Biology concepts.

H_{O2}: There is no significant difference between male and female Biology teachers in perceived ease of use of virtual for teaching biology concepts.

Table 4: Independent Sample t-test showing significant difference between male and female Biology teachers in perceived ease of use of virtual reality for teaching biology concepts

Gender	N	X	SD	Df	T	Sig. (2-tailed)	Decision
1. Male	89	45.98	7.99	261	-.656	.513	Not Rejected
2. Female	174	45.34	6.42				

From table 4, it can be deduced that there was no significant difference between male and female Biology teachers in perceived ease of use of virtual for teaching biology concepts. This is reflected in the result: t (261) = -.656, $p > 0.05$. That is, the result of the t-value of -656 resulting in a .513 significance value, which is greater than the 0.05 alpha value. Thus, the null hypothesis is accepted. This implies that there was no significant difference between male and female Biology teachers in perceived ease of use of virtual reality for teaching biology concepts.

Discussion

Findings from the study revealed that teachers perceived the usefulness of virtual reality for teaching Biology concepts. The result disagreed with Wells and Miller (2020), that the teachers held opinions about VR technology intertwined with a considerable degree of uncertainty about the technology and its uses. But the study agreed with the Alfalah et al (2017) study on perceptions toward adopting virtual reality as a learning tool in information technology. The results showed that the end users are willing to adopt VR systems as a teaching tool. The finding conforms with Khukalenko et al (2022) study on teachers' perceptions of using virtual reality technology in classrooms. The study showed that teachers had moderately positive perceptions toward the use of VR for instruction. Similarly, the result of this study supported Putra et al (2020) findings that the teachers' perception toward virtual reality in general was very positive.

The result of this study indicated that Biology teachers perceive the ease of use of virtual reality for teaching. The findings support Jones et al (2015) on middle school teachers' and students' perceived presence after learning science with a virtual reality system. The result indicated that teachers rate the virtual reality experience as realistic. This implies that both teachers and students perceived the ease of use of virtual reality as viable for instruction. The study is also in agreement with the result of Onuoha and Jolaosho (2021) that economics teachers perceived the influence of virtual reality economics on students' performance.

Furthermore, several studies have investigated the sociodemographic factors on teachers' concerns about the integration of new technologies in education. Gender differences were investigated. The result showed that there was a significant difference between male and female teachers' perceived usefulness of virtual reality for teaching Biology concepts. The findings align with the findings of Antón-Sancho et al. (2022) on the perspective of science professors' didactic use of virtual reality in Colombian Universities. The study found that there are differences in perceptions of virtual reality's usefulness for teaching between male and female university professors in Colombia.

The result of this study revealed that there was no significant difference between male and female teachers in perceived ease of use of virtual reality for teaching biology concepts. The result of the study disagreed with the study by Dirin et al. (2019) on gender differences in perceptions of conventional video, virtual reality and augmented reality. The findings revealed that there are significant differences in male and female teachers' perceived usefulness of virtual reality.

Conclusion

Based on the findings the study concluded that Biology teachers perceived the usefulness of virtual reality for teaching Biology concepts; Biology teachers perceived the ease of use of virtual reality for teaching; there was a significant difference between male and female teachers perceived usefulness virtual reality for teaching biology concepts; and there was no significant difference between male and female Biology teachers in perceived ease of use of virtual reality for teaching biology concepts.

Recommendations

Based on the result of this study, the study recommends that:

1. Biology teachers should endeavour to improve the use of virtual reality for teaching difficult concepts in Biology.
2. Biology teachers should integrate technology tools like virtual reality for teaching Biology concepts at secondary school to improve students' learning outcomes in the subject.
3. Biology teachers, both male and female, should develop more interest in using virtual reality for teaching.
4. Biology teachers, both male and female, should endeavour to have ICT skills as this will aid the ease of use of virtual reality.

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ACCESSIBILITY AND USE OF SOCIAL MEDIA FOR LEARNING AMONG UNDERGRADUATE STUDENTS IN KWARA STATE, NIGERIA

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Abstract
Social media is a new paradigm of learning process that provides the tools for learners to be in contact with classmates and the tutors outside the classroom. The study investigated the Accessibility and Use of Social Media for Learning among Undergraduates in Kwara State, Nigeria. This study was a descriptive study of the survey type. The study sample was drawn from three universities in Kwara state, Nigeria. The respondents were 287 undergraduates, 169 males and 118 females. Mean and percentage was used to answer research question 1, 2 and 3. Independent sample *t*-test was used to test hypothesis 1 and 2. All hypotheses were tested at 0.05 level of significance. Findings of the study revealed that WhatsApp is the most accessed social media tool among undergraduates students in Kwara State Nigeria. The study concluded that there is no significant difference between male and female undergraduates' accessibility and use of social media for learning. The study also revealed that there was no significant difference on accessibility and use of social media for learning by undergraduates based on school proprietorship. It was recommended among others that university authority should organize capacity building workshops to educate undergraduates on the use social media for learning in Kwara State.

Keywords: Accessibility, Usage, Social Media and Learning

Introduction

Technology has significantly changed societies, which in turn has changed the day to day activities of individuals. Societies have unprecedented access to modern technologies and use them for communication in diverse ways. Advancement in telecommunications and computer technology have dramatically improved the way educators perform their duties and the way students engage in learning activities and processes. According to Yekini (2014), Information and Communications Technology or (ICT), is often used as an extended synonym for information technology (IT), but is a more specific term that stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals), computers as well as necessary enterprise software, middleware, storage, and audio-visual systems, which enable users to access, store, transmit, and manipulate information. ICT therefore means an assemblage of all technologies by which information can be processed and communicated from one source (person) to the other using electronic devices Ugochukwu (2012). Recent trends in the existing field of ICT have brought about new and simpler ways of doing things such as inter-personal communications, data storage, teaching, learning, entertainment, games, e-governance, and a host of others (Suleiman, 2010).

The European Commission (2004) stated that the importance of ICTs is not only dependent on its creation but also making it accessible for its use in underserved populations. Many countries around the world have established organizations for the promotion of ICTs, because it is feared that unless less technologically advanced areas have access to catch up, the increasing technological advances in developed nations will only serve to exacerbate the already-existing economic gap between technological "have" and "have not" areas. Internationally, the United Nations actively promotes ICTs for Development otherwise known as (ICT4D) as a means of bridging the digital divide (Rouse, 2005).

ICTs have a significant impact on all areas of human activity (Brakel & Chisenga, 2003). Indubitably, ICTs has impacted on the quality and quantity of teaching, learning, and research in teacher education. ICT provides opportunities for students, teachers, academic and non-academic staff to communicate with one another more effectively during formal and informal teaching and learning (Yusuf, 2005). Accessibility and use of ICT are variable assets in effective education, and hence the benefit of ICT in education can be realized if students have access to ICT tools and use them pedagogically (Land & Hannafin, 2000). ICT can therefore make the school more efficient and productive thereby engendering a variety of tools to enhance and facilitate professional activities (Kirschner & Woperies 2013).

Heinich, Molenda, Russel, and Smaldino (2002) sees learning as a general term for a relatively lasting change in performance caused directly by experience. Learning can only take place when the learner takes in new information which has the same meaning for all participants and which must be communicated through a medium that both the instructor and learner have access to (Oloyede, 2008). Learning means acquiring new knowledge, behaviors, skills, values, preferences or understanding, and may involve synthesizing different types of information (Sanusi, Adelabu & Okunade 2014).

eLearning means sharing knowledge using technology, computer and network-enabled transfer of skills and knowledge (Wentling, Waight, Fleur, Wang, & Kanfer, 2000). The development of eLearning has progressed rapidly to encompass a wide range of both formal course-based packages and products together with a huge variety of complementary or alternative eLearning techniques, such as sharing knowledge or links to resources via social media sites and participating in online lectures, web seminars (webinars), podcasts or micro-blogging Chartered Institute of Personnel and Development (CIPD, 2014). eLearning incorporates synchronous or asynchronous access and may be distributed geographically with varied limits of time (Wentling et. al, 2000). Synchronous eLearning means that all students and instructors are logged on at the same time and communicate directly and virtually with each other for class to commence. Synchronous eLearning events include live web-casts, chat rooms application sharing and whiteboard sessions. Asynchronous eLearning means the communication between participants does not occur simultaneously. The learning content or courseware is served from a web server and delivered on demand to the learner's workstation, learners can thus take courses at his own pace anytime. Examples of this model include taking a self-paced course, posting messages to a discussion group, sometimes called distributed learning (Wentling et. al., 2000).

More recent trends encompass the development of gaming technology to support learning, artificial intelligence and the use of cloud computing, including the potential to deliver learning according to user requirements via the internet rather than by in-house computing systems (CIPD, 2014). It is therefore important to consider how global, local, historical, cultural, social, and individual factors might impact on how eLearning and blended learning play out (Liu & Hwang, 2009). Most of the learners make use of a group of internet-based applications that build on the ideological and technological foundations of Web 2.0, which allow the creation and exchange of user-generated content for eLearning (Andreas & Haenlein, 2010).

Web 2.0 describes World Wide Web sites that use technology beyond the static pages of earlier Web sites (O'Reilly, 2006). The term was coined in 1999 by Darcy DiNucci a consultant on electronic information design (information architecture) in her article, "Fragmented Future". Kaplan and Haenlein (2010) defined web 2.0 as a web-based platform whereby content and applications are continuously modified by all users in a participatory and collaborative way. At this time, applications belonging to the era of Web 1.0, like personal web pages, encyclopedias and content publishing are replaced by blogs, wikis, and collaborative projects in Web 2.0. O'Reilly in Anderson, (2007) discussed the principles on which Web 2.0 is based. These include the web as platform, harnessing collective intelligence, data is the next 'Intel inside', end of the software release cycle, lightweight programming models, software above the level of single device, and rich user experiences.

Social media is a component of the web 2.0. In 2004, the term began its rise in popularity when O'Reilly Media and MediaLive hosted the first Web 2.0 conference. In their opening remarks, Battelle and O'Reilly (2004) outlined their definition of the web as platform, where software applications are built upon the web as opposed to upon the desktop. The unique aspect of this migration, they argued, is that the activities of users generating content in the form of ideas, text, videos, or pictures could be "harnessed" to create value.

Figure 1: Classi
Source: ifood.tv, (2012).

Social media have become important means of communication because they allow communication with buddies and coworkers so easily and effectively. Social media is a group of internet-based applications that build on the ideological and technological foundations of web 2.0, which allows the creation and exchange of user-generated content (Kaplan & Haenlein, 2010). It is also defined by Bryer and Zavatarro (2011) as technologies that facilitate social interaction, make possible

collaboration, and enable deliberation across stakeholders. It also strengthens the ties between people of those systems (Waleed & Mohd, 2013).
Social media is a form of electronic communication which facilitates interaction based on certain interests and characteristics. Social media are media for social interaction, using highly accessible and scalable publishing techniques. Social media use web-based technologies to transform and broadcast media monologues into social dialogues (Danny, 2010). Kaplan and Haenlein (2010) classified social media into six different categories which are; Collaborative projects such as (wikipedia), blogs and microblogs such as (twitter), content communities such as (YouTube), social networking sites such as (Facebook), virtual game-world such as (world of war craft) and lastly, virtual social worlds such as (second life).

Purpose of the Study

The main purpose of the study was to determine accessibility and use of social media for learning among undergraduates in Kwara State. Specifically, the study:

a. investigated the social media undergraduates have access to.
b. determined whether undergraduates use of social media for learning.
c. investigated the frequency of use of social media by undergraduate for learning
d. examined the differences in the social media male and female undergraduates access for learning.
e. investigated the influence of school proprietorship on the social media undergraduates' access for learning.

Research Questions

Based on the purpose of the study, the following research questions were answered

1. What social media do undergraduates have access to?
2. Do undergraduates use social media for learning?
3. How frequently do the undergraduates use social media for learning?
4. Is there any difference on the social media undergraduates' access for learning based on gender?
5. Does school proprietorship of undergraduates have influence social media they access for learning?

Research Hypotheses

H_{O1}**:** there is no significant difference between male and female undergraduates' access to social media for learning.

H_{O2}**:** there is no significant difference in the social media undergraduates' access for learning based on school proprietorship.

Methodology

The study covered all undergraduates in Nigerian Universities on the accessibility and use of social media for learning. It was limited to three (3) Universities in Kwara State. Random sampling technique was used to select samples from 46,776 undergraduates. A total of 296 undergraduates were selected from the total number of students in the selected universities during the period of the study. Israel (2013) model was used to determine sample size of two hundred and ninety six (296) respondents from the three universities which were randomly selected. The sample selection of the students was based on Israel (2013) Model. A researcher designed questionnaire titled "Accessibility and Use of Social Media for Learning among Undergraduates in Kwara State, Nigeria" (AUSMLU). The choice of the questionnaire for the collection of data in this study was based on the fact that most related studies reviewed in chapter two adopted the use of questionnaire for the collection of data. The instrument comprised of three sections: Section A contains basic information about the respondents such as name of institution, department and gender. Section B contains list of social media tools such as WhatsApp, 2go, Badoo, BBM, Facebook and Google+. The instrument for this study was validated by experts in educational technology in the university of Ilorin before it was administered. All corrections and comments made by the validators were used to modify the questionnaire. In order to achieve the reliability of the research instrument, the questionnaire was administered on 29 undergraduates in Ladoke Akintola University of Technology (LAUTECH), Ogbomosho, Oyo State and collected immediately. Cronbach Alpha was used to test the reliability of the instrument and each of the variables identified in this study. The instrument had reliability co-efficient of 0.76. This shows that the instrument is reliable. Data was analyzed using descriptive and inferential statistics. Mean and percentage was used to answer research question 1 to 5 while Independent sample *t*-test was used to test hypothesis 1 and 2 All the hypotheses were tested at 0.05 level of significance.

Results

Research Question 1

What social media do undergraduates have access to?

Table 1 showed the percentage distribution of respondents on the social media they access for learning. It shows the lists of social media, number of respondents that access them and their percentages.

Ta ble 1: Percentage Distribution of Respondents on the social media they accessed

S/N	Social Media	No of respondents	%
1	2go	165	57.5
2	Badoo	71	24.7
3	BBM	224	78.0
4	Del.icio.us	29	10.1
5	Digg	20	6.9
6	Edu 2.0	42	14.6
7	Eskimi	113	39.3
8	Facebook	266	92.6
9	Flickr	59	20.5
10	Foursquared	39	13.5
11	Friendsters	47	16.3
12	Google+	228	79.4
13	Instagram	191	66.5
14	LinkedIn	77	26.8
15	Myspace	75	26.1
16	Pinterest	32	11.1
17	Secondlife	30	10.4
18	Skype	180	62.7
19	Slideshare	51	17.7
20	Technorati	42	14.6

S/N	Social Media	No of respondents	%
21	Twitter	214	74.5
22	Twoo	50	17.4
23	Viber	125	43.5
24	Vine	43	14.9
25	WeChat	127	44.2
26	WhatsApp	267	93.0
27	Wikipedia	199	69.3
28	Wordpress	69	24.0
29	World of Warcraft	50	17.4
30	YouTube	236	82.2

Table 1 revealed that WhatsApp with 267 (93.0%) is accessed the most by the respondents. This was followed sequentially by Facebook with 266 (92.6), YouTube 236 (82.2%), Google+ 228 (79.4), BBM 224 (78%), Twitter 214 (74.5%), Wikipedia 199 (69.3%), Instagram 191 (66.5%), Skype 180 (62.7%), 2go 165 (57.5%), WeChat 127 (44.2%), Viber 125 (43.5%), Eskimi 113 (39.3%) respondents that accesses them respectively. Other social media like LinkedIn, Myspace, Badoo, Wordpress, Flickr, Slideshare, Twoo, World of Warcraft, Friendsters, Vine, Edu 2.0, Technorati, Foursquared, Pinterest, Secondlife, Del.icio.us and Digg were accessed by less than 100 respondents.

Research Question 2

Do undergraduates use social media for learning?

Table 2: Undergraduates Used of Social Media for Learning

S/N	Use Social Media for Learning	Mean ($\overline{X}$)
1	Social media has the potential of complementing classroom lectures	3.22
2	Gaining knowledge is cheaper through discussions on social media	3.13
3	Social media has improved my technology literacy level	3.44
4	I can now disseminate knowledge and information to colleagues and friends with social media	3.55
5	I have developed better means of conducting researches through the use of social media	3.36
6	Social media has increased my reasoning ability in academics	3.16
7	Social media has changed my learning style	2.96
8	Social media helps in establishing enduring relationships with colleagues and friends	3.25
9	Social media has improved my academic performance	2.97
10	Social media has helped in building networks for career development	3.18
11	Online storage keeps my learning materials secured and safe	3.22
12	Social media has enhanced my communication competency with colleagues	3.23
13	Through the use of social media, I can now explore beyond the limit of textbooks	3.28
14	Social media has created opportunity to effectively present ideas to colleagues	3.25
15	Gaining knowledge is faster through discussions on social media	3.18
	Grand Mean ($\overline{X}$)	3.23

Table 2 revealed that item 4 has the highest mean value of 3.55 which sought to know if respondents can now disseminate knowledge and information to colleagues and friends with social media. This was followed by item 3 which states that social media has improved my technology literacy level with a mean score of 3.44. Item 5 sought to know if better means of conducting researches through the use of social media is developed had a mean of 3.36. It could also be noted in item13 which sought to know if the use of social media made respondents explore beyond the limit of textbooks and item 8 Social media helps in establishing enduring relationships with colleagues and friends had a mean score of 3.28 and 3.25 respectively. On the general note, the grand mean score for the respondents use social media for learning was 3.23. Using 2.0 as the bench mark, it could be deduced that the respondents generally using use of social media for learning.

Research Question 3

How frequently do the undergraduates use social media for learning?

Table 3: Undergraduates Frequency of Use of Social Media for Learning

S/N	Social Media	Mean($\bar{X}$)
1	2go	2.06
2	Badoo	1.44
3	BBM	3.00
4	Del.icio.us	1.20
5	Digg	1.11
6	Edu 2.0	1.31
7	Eskimi	1.71
8	Facebook	3.49
9	Flickr	1.41
10	Foursquared	1.26
11	Friendsters	1.35
12	Google+	3.01
13	Instagram	2.66
14	LinkedIn	1.56
15	Myspace	1.55
16	Pinterest	1.22
17	Secondlife	1.23
18	Skype	2.26
19	Slideshare	1.34
20	Technorati	1.29
21	Twitter	2.78
22	Twoo	1.34
23	Viber	1.88
24	Vine	1.33
25	WeChat	1.97
26	WhatsApp	3.58
27	Wikipedia	2.66
28	Wordpress	1.52
29	World of Warcraft	1.38
30	YouTube	2.93
	Grand Mean ($\bar{X}$)	1.89

Table 3 revealed that item 26 has the highest mean value of 3.58, meaning that WhatsApp was frequently used social media tool for learning among the respondents. This is followed sequentially by Facebook with a mean value of 3.49, Google+ (3.01), BBM (3.00), YouTube (2.93), Twitter (2.78), Instagram (2.66), Wikipedia (2.66), Skype (2.26), 2go (2.06), and WeChat (1.97). Other social media like Viber, Eskimi, LinkedIn, MySpace, and Wordpress had their mean less than the grand mean of 1.89.

Hypotheses Testing

Hypothesis One

H_{O1}: There is no significant difference between male and female undergraduates access to social media for learning.

To establish whether significant difference existed between the social media male and female undergraduates' access for learning, data was analyzed using independent sample t-test. The result of the analysis was as shown in Table 4.

Table 4: Undergraduates' Access to Social Media for Learning Based on Gender

Gender	No	$\overline{X}$	SD	df	t	Sig. (2-tailed)	Decision
Male	169	1.61	0.18	285	-.033	0.97	Accepted
Female	118	1.61	0.19				

Table 4 shows that t (285) = -.033, p = 0.97. This implies that the stated null hypothesis was accepted. This was as a result of the t-value of -.033 resulting in 0.97 significant value which was greater than 0.05 alpha value. The hypothesis there is no significant difference between male and female undergraduates' access to social media for learning was accepted.

Hypothesis Two

H_{O2}: there is no significant difference in the social media undergraduates' access for learning based on school proprietorship.

In an attempt to establish whether significant difference exists between the social media federal, state and private university undergraduates' access for learning, data were analyzed using Analysis of variance (ANOVA). The result of the analysis was as shown in Table 5.

Table 5: Social Media Undergraduates' Access for Learning Based on School Proprietorship

	Sum of squares	Df	Mean square	F	Sig.
Between Groups	.16	2	.08	2.36	.10
Within Groups	9.43	284	.03		
Total	**9.59**	**286**			

Table 5 indicated that there was no significant difference in the social media undergraduates' access for learning based on school proprietorship. {F (2, 284) =2.36, p = .10}.That is, the significance value (.10) was found to be greater than the alpha value (0.05). This means that the stated null hypothesis was accepted. By implication, the null hypothesis was established thus: No significant difference in the social media undergraduates' access for learning based on school proprietorship

Discussion of Findings

The social media undergraduates accessed for learning was examined in research question 1. Hypothesis 1 also stated that there is no significant difference between male and female undergraduates access to social media for learning. Finding shows that social media such as WhatsApp, Facebook, YouTube, Google+, BBM, Wikipedia, Instagram, Skype, 2go, WeChat, Viber, and Eskimi among others were accessed by the respondents. The results of the *t*-test established no significant difference between male and female undergraduates access to social media for learning was accepted. Some previous work also supported this findings, for instance, social network-based learning (WhatsApp, Facebook, BBM) (Wodzicki, Scwammlein & Maskaliuk, 2012). Lee and McLoughlin (2007) stated that access of social media tools goes beyond gender stereotypes. Clariana and Wallace (2002) also concluded that no difference exist in the administration mode of computer based test based on gender. It can therefore be established that there was no significant difference between the social media undergraduates' access for learning based on gender. The use of social media for learning was examined in research question 2. Such activities like dissemination of knowledge and information to colleagues and friends, improving technology literacy level, better means of conducting researches were itemized. The resulting mean score established that undergraduates use social media for learning. In an attempt to examine if difference exists between federal, state and private university undergraduates use of social media for learning, data were analyzed using One-way Analysis of Variance (ANOVA). The result of the analysis showed that there is no significant difference. The outcome of this study was supported by the study of Ala-Mutka (2010) that social media applications provide easy, fast and efficient ways to access a great diversity of information and situated knowledge. Jacobsen and Forste (2011) also reported that students use social media platforms during classes and homework. Onasanya, Yahaya, Akingbemisilu and Ayelaagbe (2013) investigated the relationship between online social networking and the academic achievement of students' in three universities (state, private and federal) in Kwara State, Nigeria. The result of the findings indicated that there is no significant relationship between students' use of social networking sites and their academic achievement when universities are compared. By implication, there is no significant difference on the influence of school proprietorship in the use of social media for learning by undergraduates.

Conclusions

This study examined the accessibility and use of social media for learning among undergraduates in Kwara state. The result obtained from the data gathered and analyzed in this study indicated that undergraduates' access and use social media for learning. The findings of this research established that WhatsApp was accessed the most among the respondents. It revealed that various educational ways in which social media could be of benefit to undergraduates towards learning is welcomed. The result revealed that social media is been accessed and used always for learning among undergraduates.

Recommendations

Based on the findings and conclusions of this study, the following recommendations were made;

1. Students should be encouraged in the use of Social Media for learning since they are useful for learning;
2. Faculties can learn from this study and fashion out ways of applying various social media tools to help students for course activities.

3. The school authority should organize capacity building workshops to educate students on the use of social media for learning;
4. Stakeholders in distance education should investigate the capacity of social media in handling distance learning.
5. Curriculum planners and developers should include in the curriculum the use of social media as a medium of learning.

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LEVEL OF EDTECHPRENEURSHIP COMPETENCE AMONG PRE-SERVICE BUSINESS EDUCATION TEACHERS AT THE FEDERAL COLLEGES OF EDUCATION

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Abstract

The rapid integration of technology into education has given rise to *edtechpreneurship*—a convergence of educational practice, technological innovation, and entrepreneurial thinking. This study examined the levels of technology competence, entrepreneurship competence, and edtechpreneurship competence among pre-service business education teachers at the Federal College of Education (Technical) Akoka, Nigeria. Using a descriptive survey design, data were collected from a stratified random sample via the Edtechpreneurship Competence Questionnaire (ECQ) and analyzed with descriptive and inferential statistics. Findings revealed moderate to high technology competence, particularly in common digital literacy skills, but weaker proficiency in technical ICT tasks. Entrepreneurship competence was moderate, with strengths in basic business understanding and leadership, yet deficiencies in financial management and risk assessment. Edtechpreneurship competence was moderate to low, with limited ability to create, manage, or monetize technology-based educational ventures. The results underscore a skills gap in merging technological and entrepreneurial capabilities, suggesting the need for curriculum reforms that integrate hands-on, innovation-driven training in educational technology entrepreneurship. This will better prepare future business educators to drive digital transformation and foster entrepreneurial mindsets in Nigerian classrooms.

Introduction

The landscape of education is undergoing a profound transformation, driven by the relentless pace of technological innovation. The integration of technology into teaching and learning processes, commonly referred to as educational technology or edutech, has become an indispensable component of modern pedagogy (Bond, 2024). This paradigm shift necessitates a new breed of educators who are not only adept at utilizing technology but also possess an entrepreneurial spirit to innovate and create solutions within the educational sphere. This emerging field, termed "edtechpreneurship," signifies the convergence of education, technology, and entrepreneurship, focusing on the development and deployment of technological solutions to address educational challenges and foster novel learning opportunities (Valdez & Barrera, 2020). In an increasingly interconnected and digitally-driven world, the role of teachers has expanded significantly. Beyond their traditional responsibilities of imparting knowledge, educators are now expected to be facilitators of innovation, critical thinkers, and agents of change who can harness the power of technology to enrich the learning experience and prepare students for the complexities of the 21st-century workforce. This imperative is particularly pronounced for business education teachers, whose mandate includes cultivating entrepreneurial mindsets and practical business skills in their students. The symbiotic relationship between business education and edtechpreneurship underscores the critical need for pre-service business education teachers to demonstrate a high degree of competence in leveraging technological tools in conjunction with entrepreneurial principles to drive educational advancement.

Federal College of Education (FCET) Akoka stands as a pivotal institution in Nigeria's educational ecosystem, responsible for training a significant portion of the nation's future educators. The preparedness of its pre-service business education teachers to navigate and contribute to the evolving educational landscape, particularly in the realm of edtechpreneurship, is therefore of paramount importance. Their competence in this area directly impacts their ability to effectively integrate technology into their teaching, inspire entrepreneurial thinking in their students, and ultimately contribute to the socio-economic development of the nation.

Statement of the Problem

Despite the increasing global emphasis on technology integration and entrepreneurial skills in education, there remains a discernible gap in empirical research concerning the specific levels of edtechpreneurship competence among pre-service business education teachers within Nigerian higher education institutions, such as FCET Akoka. While general studies on technology in education and entrepreneurship exist, there is a lack of focused investigation into how these two critical areas converge to form edtechpreneurship competence in future educators. This gap is particularly significant given the unique challenges and opportunities presented by the Nigerian educational context, where access to technology and entrepreneurial development initiatives may vary.

Without a clear understanding of the current levels of technology competence, entrepreneurship competence, and their combined manifestation as edtechpreneurship competence among pre-service business education teachers at FCET Akoka, it is challenging to design effective curriculum enhancements, targeted training programs, and supportive policies. This deficiency could lead to a cohort of new teachers who are not fully equipped to prepare students for the demands of a technologically advanced and entrepreneurially driven economy. Therefore, this study is meticulously designed to bridge this critical knowledge gap by systematically investigating these competencies among prospective educators at FCET Akoka, providing empirical data essential for informed educational reforms.

Research Questions

1. What is the current level of technology competence among pre-service business education teachers at Federal College of Education (FCET) Akoka?
2. What is the current level of entrepreneurship competence among pre-service business education teachers at Federal College of Education (FCET) Akoka?
3. What is the current level of edtechpreneurship competence among pre-service business education teachers at Federal College of Education (FCET) Akoka?

Literature Review

Conceptual Framework of Edtechpreneurship

Edtechpreneurship, a relatively nascent but rapidly expanding field, represents the intersection of education, technology, and entrepreneurship. It encompasses the creation, development, and implementation of innovative technological solutions to address educational needs and challenges (Valdez & Barrera, 2020). This concept moves beyond mere technology integration in education; it involves an entrepreneurial mindset that seeks to identify opportunities, take calculated risks, and develop sustainable models for educational advancement through technology. Key aspects of edtechpreneurship include the development of e-learning platforms, educational software, virtual reality tools for learning, and other digital resources designed to enhance teaching and learning processes (García-Peñalvo et al., 2020).

Technology Competence in Education

Technology competence in education refers to an educator's ability to effectively use, integrate, and adapt various technological tools and resources to enhance teaching, learning, and administrative tasks. This encompasses a broad range of skills, from basic digital literacy to advanced pedagogical applications of technology. According to Koehler and Mishra (2009), Technological Pedagogical Content Knowledge (TPACK) is a framework that highlights the complex interplay between technology, pedagogy, and content knowledge, emphasizing that effective technological integration requires more than just knowing how to use a tool; it demands an understanding of how technology can transform teaching and learning within specific subject areas. For pre-service teachers, developing robust technology competence is crucial for creating engaging and effective learning environments that prepare students for a technologically advanced world (Tondeur et al., 2017). This includes proficiency in using learning management systems, multimedia creation tools, data analysis software, and collaborative online platforms.

Entrepreneurship Competence

Entrepreneurship competence involves a set of knowledge, skills, and attitudes that enable individuals to identify opportunities, create value, and manage ventures in dynamic environments. Key dimensions often include opportunity recognition, creativity, risk-taking, resource mobilization, planning, and leadership (Morris et al., 2006). In the context of education, fostering entrepreneurship competence among teachers means empowering them to be proactive, innovative, and capable of developing new educational initiatives or improving existing ones. This extends beyond traditional business creation to include social entrepreneurship and intrapreneurship within educational institutions, where educators drive change and innovation from within (Neck & Greene, 2011). For business education teachers, entrepreneurship competence is not only a personal attribute but also a core subject matter they are expected to teach and model for their students.

Edtechpreneurship Competence

Building upon technology and entrepreneurship competencies, edtechpreneurship competence specifically refers to the ability to combine technological proficiency with an entrepreneurial mindset to innovate within the educational sector. This involves identifying educational problems that can be solved through technological solutions, developing and implementing these solutions, and understanding the market dynamics of educational technology. It requires a unique blend of pedagogical insight, technical skills, and business acumen (Valdez & Barrera, 2020). An edtechpreneurially competent teacher can not only integrate existing edtech tools effectively but also conceptualize, design, and potentially develop new educational technologies or innovative pedagogical approaches that leverage technology to address specific learning needs. This competence is vital for pre-service business education teachers as they will be at the forefront of preparing students for a future where technological innovation and entrepreneurial thinking are paramount.

Business Education and Teacher Preparation

Business education plays a pivotal role in preparing individuals for careers in commerce, management, and entrepreneurship. It traditionally focuses on subjects such as accounting, marketing, economics, and business law. However, with the advent of the digital age, business education curricula have evolved to incorporate digital literacy, e-commerce, and technology management (International Society for Business Education, 2019). Teacher preparation programs in business education are thus tasked with equipping future educators not only with subject matter expertise but also with the pedagogical skills to teach these evolving concepts effectively. This includes the ability to integrate technology into their teaching methods and to foster entrepreneurial thinking among their students.

Pre-service Teacher Competence Development

The development of competence in pre-service teachers is a continuous process that involves theoretical knowledge acquisition, practical skill development, and reflective practice. For pre-service business education teachers, this includes developing a strong foundation in business principles, pedagogical strategies, and increasing technological proficiency. The integration of edtechpreneurship into teacher training curricula is essential to ensure that new teachers are prepared to navigate and contribute to the technologically driven educational landscape (Tondeur et al., 2017). This involves training in designing digital learning materials, utilizing online collaboration tools, and understanding the ethical implications of technology use in education.

Gaps in Current Research

While there is a growing body of literature on entrepreneurship education, technology integration in education, and teacher competencies, specific research on the edtechpreneurship competence of pre-service business education teachers, particularly in the context of Nigerian higher education institutions like FCET Akoka, remains limited. Existing studies often focus on general technology integration or entrepreneurship skills without specifically addressing the unique blend of competencies required for edtechpreneurship. This study aims to fill this gap by providing empirical data on the current level and dimensions of edtechpreneurship competence among this specific group of future educators, thereby contributing to the development of more targeted teacher training programs and curricula.

Methodology

This study employed a descriptive survey research design to assess the level of technology competence, entrepreneurship competence, and edtechpreneurship competence among pre-service business education teachers at Federal College of Education (FCET) Akoka. A descriptive survey design is appropriate for this study as it facilitates the collection of data from a defined population to describe existing characteristics without manipulating variables (Creswell, 2014). The target population included all pre-service business education teachers enrolled at FCET Akoka during the 2024/2025 academic session. A stratified random sampling technique was utilized to select a representative sample, ensuring proportional representation across academic years. The sample size was determined using a statistical formula, aiming for at least 30% of the total population to ensure generalizability of findings (Gay et al., 2012).

Data were collected using a structured questionnaire, the "Edtechpreneurship Competence Questionnaire (ECQ)," developed by the researchers based on identified competence dimensions. The ECQ included demographic information and Likert-scale items assessing technology, entrepreneurship, and edtechpreneurship competencies. The instrument underwent face and content validity by experts and its reliability was established through a pilot study, yielding a Cronbach's Alpha coefficient of 0.70 or higher. Descriptive statistics (mean scores, standard deviations) were used to answer research questions on competence levels, while inferential statistics (independent samples t-test, ANOVA) were applied to examine differences based on demographic variables. All analyses were conducted using SPSS version 26.0, with a significance level of $p < 0.05$. Ethical considerations, including informed consent, anonymity, confidentiality, and institutional permission, were strictly adhered to throughout the study.

Results

Research Question 1: What is the current level of technology competence among pre-service business education teachers at Federal College of Education (FCET) Akoka?

S/N	Items	Mean	Std. Dev
1	I can operate a computer system for academic tasks.	3.15	0.65
2	I can use Microsoft Word, Excel, and PowerPoint effectively.	3.20	0.60
3	I can browse the internet to find academic/professional content.	3.30	0.58
4	I can use educational tools like Google Classroom or Zoom.	2.90	0.75
5	I can troubleshoot basic hardware/software issues.	2.60	0.81
6	I can integrate technology into lesson planning and delivery.	2.80	0.69
7	I am confident using smartphones/tablets for educational purposes.	3.05	0.70
8	I know how to install and update educational applications.	2.70	0.76
9	I can use cloud storage and file sharing services (e.g., Google Drive).	2.85	0.74
10	I can ensure safe and ethical use of digital tools.	2.95	0.68

Based on the analysis of responses to Research Question 1, the findings reveal that pre-service business education teachers at FCET Akoka exhibit a moderate to high level of technology competence. The highest mean scores were recorded in the ability to browse the internet for academic content (Mean = 3.30), use Microsoft Office tools (Mean = 3.20), and operate a computer for academic tasks (Mean = 3.15), indicating strong proficiency in general digital literacy. However, lower mean scores in troubleshooting hardware/software issues (Mean = 2.60) and installing/updating educational applications (Mean = 2.70) suggest weaker competence in more technical aspects of ICT usage. Overall, the results show that while the students are comfortable with commonly used educational technologies, there is room for improvement in their deeper technical and integrative digital skills.

Research Question 2: What is the current level of entrepreneurship competence among pre-service business education teachers at Federal College of Education (FCET) Akoka?

S/N	Items	Mean	Std. Dev
1	I understand basic business concepts.	3.10	0.61
2	I can identify business opportunities within my environment.	2.85	0.66
3	I can develop a basic business plan.	2.75	0.73
4	I can calculate the cost and price of products/services.	2.65	0.70
5	I know how to market goods and services.	2.70	0.78
6	I can keep basic financial records.	2.55	0.74
7	I can make decisions and solve problems in business.	2.80	0.69
8	I can lead a team or small business group effectively.	2.90	0.63
9	I understand risks and how to manage them.	2.60	0.71
10	I am confident I can start a small business.	2.95	0.62

The analysis of Research Question 2 indicates that pre-service business education teachers at FCET Akoka possess a moderate level of entrepreneurship competence. Respondents demonstrated relatively high competence in understanding basic business concepts (Mean = 3.10), showing confidence in starting a small business (Mean = 2.95), and leading a team effectively (Mean = 2.90). However, they showed lower competence in maintaining financial records (Mean = 2.55), managing risks (Mean = 2.60), and pricing products or services (Mean = 2.65). These findings suggest that while students have foundational entrepreneurial awareness and leadership potential, their practical business management skills—particularly in finance and risk management—need further development to fully prepare them for entrepreneurial success.

Research Question 3: What is the current level of edtechpreneurship competence among pre-service business education teachers at Federal College of Education (FCET) Akoka?

S/N	Items	Mean	Std. Dev
1	I can develop educational content using digital tools.	2.55	0.79
2	I can create and manage an online education platform or blog.	2.35	0.83
3	I can offer tutoring or training services online.	2.45	0.77
4	I can monetize digital educational content.	2.20	0.82
5	I can use social media for promoting educational services.	2.90	0.69
6	I understand how to build a digital brand.	2.40	0.75
7	I can use technology to identify and solve educational problems.	2.65	0.72
8	I can collaborate online to develop education-based businesses.	2.50	0.80
9	I am familiar with platforms for selling digital education products.	2.10	0.85
10	I believe I can start an education technology-based business.	2.30	0.78

The analysis of Research Question 3 shows that pre-service business education teachers at FCET Akoka have a moderate to low level of edtechpreneurship competence. The highest mean score was recorded for using social media to promote educational services (Mean = 2.90), indicating some familiarity with online engagement. However, the lowest scores were observed in familiarity with platforms for selling digital education products (Mean = 2.10) and monetizing digital content (Mean = 2.20), suggesting limited exposure to the business side of educational technology. Additionally, their ability to manage an online platform (Mean = 2.35) and confidence in starting an edtech-based business (Mean = 2.30) were also relatively low. These results imply that while students are somewhat comfortable using digital tools for educational purposes, they lack the entrepreneurial acumen to turn these tools into viable business ventures—highlighting a critical skills gap in edtechpreneurial readiness.

Discussion

The findings from this study reveal varied levels of competence across the three domains of technology, entrepreneurship, and edtechpreneurship among pre-service business education teachers at FCET Akoka. The results indicate a moderate to high level of technology competence, with students demonstrating strong abilities in using common digital tools such as Microsoft Office, internet browsing, and smartphones for academic purposes. This aligns with studies like Yusuf et al. (2020), which reported that Nigerian teacher trainees are increasingly digitally literate due to exposure to ICT tools in their academic environment. However, their relatively lower competence in technical tasks such as troubleshooting or installing software suggests a need for more hands-on training to build practical ICT skills necessary for modern teaching and digital innovation.

In contrast, students displayed only a moderate level of entrepreneurship competence, and a moderate-to-low level of edtechpreneurship competence. While they show understanding of basic business principles and confidence in small business leadership, their low scores in financial management, risk assessment, and especially digital monetization skills, highlight a significant skills gap. The particularly low competence in creating and managing digital educational businesses reflects a lack of integration between ICT training and entrepreneurial education. This is consistent with findings by Udu and Udu (2021), who stressed that Nigerian teacher education programs often fail to adequately prepare students for tech-driven entrepreneurial ventures. These results emphasize the need for curriculum reforms that blend digital skills development with entrepreneurship, particularly in education technology, to enhance job readiness and innovation among future business educators.

Conclusion

In conclusion, the study reveals that while pre-service business education teachers at FCET Akoka demonstrate a moderate to high level of technology competence and a fair grasp of general entrepreneurial skills, their edtechpreneurship competence remains relatively low. This indicates that although they are familiar with using digital tools for learning and basic business concepts, they lack the practical ability to merge these skills into profitable, tech-driven educational ventures. The findings highlight a critical need to enhance teacher education curricula by integrating hands-on, innovation-focused training in edtech entrepreneurship to better equip future educators for the demands of a digital and entrepreneurial education landscape.

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ASSESSMENT OF INFORMATION AND COMMUNICATION TECHNOLOGY LITERACY SKILLS AND COMPETENCE LEVEL AMONG IN-SERVICE TEACHERS IN NIGERIA

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Abstract

The development and innovation of ICT in teaching-learning process is an investment for the advancement of education. The way pre-service teachers are taught affects greatly the way they teach. Despite ICT integration into their training, poor implementation in the classroom is pervading and his might be due to the levels of literacy skills and competence in the use of ICT. This study assessed the ICT literacy skill and competence levels of in-service trainee teachers in Nigeria. This study is a descriptive survey research and a convenience sampling technique was used to select two hundred and eighty three in-services teachers from Institute of Education, University of Ilorin. The in-service teachers are from different parts of the country on continuous education progranmme at the Institute of Education. A researcher-designed questionnaire of sections A-C was used to sample the opinion of respondents. The questionnaire was validated by three educational technology lecturers and the Cronbach's Alpha coefficient reliability is 0.83. Six research questions were raised and responses were analysed using frequency count and percentages. The result showed that the in-service trainee teachers possess high literacy skill but their competence level is at a lower proficiency. Therefore, it is recommended that in-service trainee teachers need to improve on their competence level by attending relevant workshops in order to meet up with UNESCO competence framework in information and communication technologies (ICT).

Introduction

Information and Communication Technology (ICT) is computer based tools used by people to work with information and communication processing needs of an organization (Yusuf & Balogun, 2011). United Nations Education and Socio-Cultural Organization (UNESCO, 2004) defined Information and Communication Technologies (1CTs) as technologies used to communicate and to create, manage and distribute information. This definition of ICTs might include computers, the Internet. telephones, television, radio and audiovisual equipment. ICT refers to the applications found on most thin client computers, internet and other electronic delivery systems such as radio, digital televisions, and projectors among others that teachers can use as pedagogical tools (Ndibalema, 2014). The use of ICT brings about a powerful learning environment and it transforms the learning and teaching process for students to deal with knowledge in an active, self-directed and constructive way (Volman & Eck, 2001), According to Singh and Chan (2014), ICT is seen as an important instrument that promotes and supports existing and new ways of teaching-learning process. Murray (2008) opined that information and communication technologies are changing everything, transforming organizations. and redefining the skills and talents needed to succeed in the 21st century. In the submission of Adodo (2012), tertiary institutions are relevant actors in the social system in the supply of new professionals that possess universalistic skills for better identification of social and economic responsibilities; including its roles among others is education and leaning.

Higher education institutions, especially those in the West, have adopted ICT as a means to transmit upon students the knowledge and skills demanded by 21st century educational advancement (United Nations Educational, Scientific and Cultural Organization, UNESCO, 2009). The development and innovation of ICT in teaching-learning process is directed teachers because they are the people who use these ICT investments for the development of education (Singh & Chan, 2014). The way pre-service teachers are taught affects greatly the way they teach, and despite ICT integration in their training, it is poorly implemented in the classroom (DeGanarro, 2010: Martinez, 2009). The ICT policy goal of technology literacy approach is to prepare learners, citizens, and a workforce that is capable of taking up new technologies to support social development and improve economic productivity (UNESCO, 2008). ICT proficiency is the ability to use technological tools and networks to define information need, access, manage, integrate and evaluate information. The ability to access, evaluate, organize and use information from a variety of sources is known as Information literacy (Humes, 2003). The concept of minimum information and communication literacy skills requires an ICT user to be able to locate, evaluate, and communicate information as an important outcome of teaching-learning process (Zelman, et al. n.d.). ICT literacy otherwise known as technological literacy can be considered as the ability to know and to use technology adequately, and it also refers to the application of technology effectively as a tool to research, organise, evaluate and communicate information (Oye, A.lahad, & Ab.Rahim, 2012).

The Educational Testing Service (ETS, 2004) defines ICT literacy as the ability to use digital technology, communication tools, and networks to access, manage, integrate, evaluate, and create information. According to Oye, Alahad, and Ab. Rahim (2012), ICT literacy can be grouped into three categories: the first involves knowledge of technology; the second relates to the practical skills required to use the technology; and the third concerns the attitudes shaped by critical reflection on its use. Similarly, Lowe and McAuley (2000) describe ICT literacy as the set of skills and competencies that enable individuals to use computers and related technologies to achieve personal, educational, and workplace goals.

According to UNESCO (2008), teachers who demonstrate competence within the knowledge creation approach are expected to design ICT-based learning resources and environments; use ICT to foster knowledge construction and critical thinking in students; support continuous reflective learning; and build knowledge communities among both students and colleagues. Such teachers are also positioned to take on leadership roles by training peers and shaping a shared vision of their school as an innovative, ICT-enriched learning community. Similarly, ETS (2001) developed a framework for ICT literacy based on an international panel's definition, which describes ICT literacy as the ability to use digital technology, communication tools, and networks to access, manage, integrate, evaluate, and create information essential for functioning effectively in a knowledge-based society.

The use of Information and Communication Technologies (ICT) as learning tools is intended to help students develop competence in everyday problem-solving (Lowther, Ssuppo, Moyo, & Morrison, 1998). However, no matter how much technology is available to teachers, it is the right attitude that enables them to build the competence required for effective integration into the teaching and learning process (Kadel, 2005). Competence, as defined by Danner and Pessu (2013), is the ability to combine and apply relevant attributes to specific tasks in particular contexts. These attributes include knowledge, values, skills, personal dispositions, sensitivities, and the capability to apply them appropriately in real-world situations (Commonwealth Department of Education, Science and Training, 2002). In the context of education, ICT competence refers to what teachers should know and be able to do in order to guide the meaningful use of technology in their professional practice (Danner & Pessu, 2013). Kirschner and Woperies (2003) outlined key ICT

competencies teachers must possess. These include: using ICT for personal purposes, mastering a variety of ICT tools, employing ICT as cognitive tools ("mind tools"), using ICT for instructional delivery, applying ICT in various assessment strategies, and understanding the broader policy and educational implications of ICT use. Similarly, UNESCO (2008), in its ICT competence standards, emphasized that ICT literacy contributes to the provision of quality learning resources for all. It enhances literacy skills and promotes the use of a range of hardware and software tools for both personal and community development.
Prendes, et al., (2012) noted that for a teacher to be considered ICT-competent, they must demonstrate competence in at least five closely related areas: the pedagogical dimension; understanding the social, ethical, and legal aspects of ICT use in teaching; skills for ICT-based school management; the use of ICT for professional development; and technical know-how. Yusuf and Balogun (2011) further stressed that successful integration of ICT in the school system depends largely on teachers' competence and attitudes toward the role of modern technologies in teaching and learning. Assessing the ICT literacy skills and competence levels of in-service trainee teachers is therefore essential for ensuring effective ICT integration in education. According to Zelman, et al., (n.d.), ICT literacy assessments focus on evaluating cognitive problem-solving, critical reasoning, and critical reading skills as they relate to using technology to manage information. They explained that such assessments measure ICT literacy through seven core processes, which represent key elements of problem-solving and critical thinking. These components include defining, accessing, managing, integrating, evaluating, and creating information.

Yusuf (2005) reported that many teachers in Nigerian secondary schools lack competence in basic computer operations and the use of common software applications. If teachers are to effectively integrate ICT into the school curriculum, adequate preparation must begin at the pre-service teacher education level. While several studies have explored ICT integration among pre-service teachers, focusing on the factors that promote or hinder its adoption in the teaching-learning process (Suliman et al., 2014; Markauskaite, 2005; Yusuf & Balogun, 2011; Danner & Pessu, 2013), there is limited research specifically addressing the ICT literacy skills and competence levels of in-service trainee teachers in Nigeria. It is on this basis that the present study seeks to assess the ICT literacy and competence levels of this group.

Research Questions

1. To what extent can in-service trainee teachers use ICT tools to access information?
2. To what extent can in-service trainee teachers manage information using ICT tools?
3. To what extent can in-service trainee teachers integrate ICT tools in communicating information?
4. What is the competence level of in-service trainee teachers in evaluating information using ICT tools?
5. What is the competence level of in-service trainee teachers in creating information using ICT tools?
6. What is the competence level of in-service trainee teachers in communicating knowledge through ICT tools?

Methodology

This study employed a descriptive survey design to assess the ICT literacy skills and competence levels of in-service trainee teachers in Nigeria. A researcher-designed questionnaire consisting of three sections (A–C) was developed and validated before administration. The reliability of the instrument was confirmed using Cronbach's Alpha, yielding a coefficient of 0.83. Section A captured the demographic information of respondents. Section B focused on ICT literacy skills, with items rated on a five-point Likert scale: Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D), and Strongly Disagree (SD). Section C assessed the competence level of in-service trainee teachers in the use of ICT tools, using a three-point Likert scale: Low Proficiency (LP), Moderate Proficiency (MP), and High Proficiency (HP). A convenience sampling technique was employed to select participants. The final sample consisted of 283 in-service trainee teachers (82 males and 201 females) drawn from the Institute of Education, University of Ilorin. Data collected were analyzed using frequency counts and percentages.

Result

Research Question 1: To what extent can in-service trainee teachers use ICT tools to access information?

Table 1: In-service Trainee Teachers' Responses on Using ICT Tools to Access Information

SN	ACCESS INFORMATION: I can	SA (%)	A (%)	U (%)	D (%)	SD (%)	Mean
1	access the internet with my ICT tools	235 (83)	48 (17)				1.2
2	do some of my assignment online with my ICT tools	123 (43.5)	53 (18.77)	70 (24.7)	8 (2.8%)	29 (10.2)	2.1
3	use the world wide web (www) to access information	133 (47)	57 (20.1)	63 (22.3)	15 (5.3)	15 (5.3)	2.0
4	access different search engine with my ICT tools e.g Google, Yahoo	167 (59)	80 (28.3)	29 (10.2)	2 (7)	5 (1.8)	1.6

From Table 1, 100% of the respondents agreed that they could access the internet using their ICT tools. About 62.3% (SA + A) indicated that they use their ICT tools to do assignments online, while 67.1% agreed they use the World Wide Web to access information. Additionally, 87.3% of the respondents reported being able to access search engines like Google and Yahoo using their ICT tools. In summary, the findings suggest that the majority of in-service trainee teachers possess the ability to access information using various ICT tools.

Research Question 2: To what extent can in-service trainee teachers manage information using ICT tools?

Table 2: In-service Trainee Teachers' Responses on Managing ICT Tools

SN	ACCESS INFORMATION: I can	SA (%)	A (%)	U (%)	D (%)	SD (%)	Mean
1	use ICT tool to find specific information	197 (69.6)	73 (25.8)	-	-	13 (4.6)	1.4
2	use ICT tool to find relevant information	201 (71)	82 (29)	-	-	-	1.3
3	take part in an online chat	233 (82.3)	31 (11)	-	-	19 (5.7)	1.3
5	Download any online documents	159 (56.2)	73 (25.8)	-	-	51 (18)	1.8

5	Publish documents/files online for public or group access	93 (32.9)	67 (23.7)	14 (4.9)	89 (31.4)	20 (7.1)	2.6

From Table 2, 95.4% of the respondents reported that they can use ICT tools to find specific information, while 100% indicated they are able to find relevant information online. Furthermore, 93.3% affirmed they can participate in online chats, and 82% said they are capable of downloading online documents. However, only 56.6% of the respondents agreed that they can publish documents or files online for public or group access, indicating a relatively lower level of proficiency in that specific task. In conclusion, the data suggests that in-service trainee teachers are generally competent in managing information using ICT tools, though their ability to publish information online remains comparatively limited.

Research Question 3: To what extent can in-service trainee teachers integrate ICT tools in communicating information?

Table 3: In-service Trainee Teachers' Responses on Integrating ICT Tools for Communication

SN	INTEGRATE ICT: I can	SA (%)	A (%)	U (%)	D (%)	SD (%)	Mean
1	send an attachment with ICT tool	117 (41.3)	73 (25.8)	6 (2.1)	59 (20.8)	28 (9.9)	2.3
2	use information from the internet in my projects and/or assignments with ICT tools	219 (77.4)	57 (20.1)	-	-	7 (2.5)	1.3
3	download a file from the internet with my ICT tools eg. Music, games	173 (61.1)	77 (27.2)	-	6 (2.1)	27 (9.5)	1.6
4	copy and paste information from searches into personal documents with ICT tools	89 (31.4)	137 (48.4)	4 (1.4)	39 (13.8)	14 (4.9)	2.1
5	save an image or graphic from an internet page	147 (51.9)	67 (23.7)	3 (1.1)	-	51 (18)	2.0
6	use a bookmark to store a useful internet web address with ICT tools	45 (15.9)	78 (27.6)	107 (37.8)	12 (4.2)	41 (14.5)	2.6
7	use my ICT tools to create a simple web page for classroom discussion	15 (5.3)	48 (17)	210 (74.2)	7 (2.5)	3 (1.1)	2.8
8	use a known web address to find useful information with ICT tools	214 (75.6)	69 (24.4)	-	-	-	1.2

From the table, 67.1% of respondents (SA + A) indicated they can send attachments using ICT tools. A substantial 97.5% reported that they are able to use information from the internet for their projects and assignments. Additionally, 88.3% of in-service trainee teachers agreed they can download documents or files such as music or games using their ICT tools, while 79.8% indicated they can copy and paste search results into personal documents. Furthermore, 75.6% of the respondents affirmed they can save images or graphics from web pages. However, only 43.5%

reported being able to use bookmarks to store useful web addresses, and 74.2% were undecided about their ability to create simple web pages for classroom use, suggesting limited proficiency in web publishing tasks. Notably, 100% of the respondents agreed they could use known web addresses to locate useful information. In summary, most in-service trainee teachers demonstrate basic ICT integration skills for communication, especially in sourcing, saving, and reusing information, but show weaker ability in higher-level tasks like bookmarking and web page creation.

Research Question 4: What is the competence level of in-service trainee teachers in evaluating information using ICT tools?

Table 4: In-service Trainee Teachers' Responses on Evaluating Information using ICT Tools

SN	EVALUATING INFORMATION	LP (%)	MP (%)	HP (%)	Mean
1	Use ICT to search for relevant information via the search engines	177 (62.5)	30 (10.8)	76 (26.9)	1.6
2	Screen online information to download useful ones	78 (27.8)	172 (42.9)	27 (2.5)	1.8
3	Navigate through the internet to get important links that is relevant to purpose	184 (65)	25 (2.2)	74 (26.1)	1.6
4	Carefully select choice of words to guide the internet search	121 (42.8)	7 (2.5)	155 (54.7)	2.1

Table 4 presents responses related to the competence level of in-service trainee teachers in evaluating information using ICT tools. A total of 62.5% of the respondents reported a low level of competence in using ICT to search for relevant information via search engines, while only 26.9% indicated high proficiency. Similarly, 65% showed low competence in navigating through the internet to access important links relevant to their purpose, with just 26.1% reporting a high level of competence. In evaluating the ability to screen online information to select useful ones, 27.8% of the respondents fell in the low proficiency category, 42.9% reported medium proficiency, and only 2.5% reported high proficiency. Interestingly, the reverse trend appears for selecting search keywords: 54.7% reported high competence in carefully choosing the right words to guide online searches, while 42.8% had low competence and only 2.5% were at a medium level. These results suggest that while many in-service trainee teachers can perform basic search-related tasks, a significant portion still struggles with more analytical tasks such as screening and evaluating the relevance or quality of retrieved information.

Research Question 5: What is the competence level of in-service trainee teachers in creating information using ICT tools?

Table 4: In-service Trainee Teachers' Responses on Creating Information with ICT Tools

SN	CREATING INFORMATION	LP (%)	MP (%)	HP (%)	Mean

1	Type and save information to create documents with ICT tools e.g. MS-Word, Excel, PowerPoint, etc.	82 (29)	36 (12.7)	165 (58.3)	2.3
2	Send saved documents as attachment through the electronic mail with ICT tools	60 (21.2)	132 (46.6)	91 (32.2)	2.1
3	Create chat group system in any of the social media platform with ICT tools	236 (83.4)	20 (7.1)	27 (9.5)	1.3
4	Edit existing audio, video or multimedia files containing useful information	141 (49.8)	116 (41)	26 (9.2)	1.6
5	Upload audio, video or multimedia files with ICT tools for online access	148 (52.3)	118 (41.7)	17 (6)	1.5

The findings in Table 5 show that competence levels among in-service trainee teachers vary across different tasks related to creating information using ICT tools. A majority (58.3%) demonstrated high competence in typing and saving documents using applications like MS Word, Excel, or PowerPoint, with only 29% at a low proficiency level. Similarly, 46.6% showed moderate competence in sending saved documents as email attachments, while 32.2% reported high competence and 21.2% were in the low category. In contrast, a large proportion (83.4%) reported low competence in creating chat groups on social media platforms, with only 9.5% indicating high proficiency in this area. Likewise, when it comes to editing existing multimedia files, 49.8% fell into the low proficiency group, 41% showed moderate ability, and only 9.2% reported high competence. For uploading multimedia content online, more than half (52.3%) indicated low competence, while 41.7% had a moderate level and just 6% reported high competence. Overall, the results suggest that while many in-service trainee teachers are relatively skilled in basic document creation and email communication, they are significantly less competent in more dynamic content creation tasks like editing or uploading multimedia files and managing social media-based information sharing.

Research Question 6: What is the competence level of in-service trainee teachers to communicate knowledge through ICT tools?

Table 6: In-service Trainee Teachers' Responses on Communicating Knowledge with ICT Tools

SN	COMMUNICATING KNOWLEDGE	LP (%)	MP (%)	HP (%)	Mean
1	Send messages through electronic mailing systeme via ICT tools, eg Yahoo mail, Google mail etc..	52 (18.4)	63 (22.3)	168 (59.4)	2.4
2	Take pictures of my surrounding and upload it to the internet	31 (11)	217 (76.7)	35 (12.4)	2.0
3	Interact with superior experts for clarification and explanation of technical terms in my field of study	213 (75.3)	40 (14.1)	30 (10.6)	1.3
4	Chat online with peers or colleagues with ICT tools on social media e.g Whatsapp, Facebook	23 (8.1)	23 (8.1)	237 (83.7)	2.7
5	Use skype, TeamViewer or other related internet calling application software	211 (74.6)	54 (19.1)	18 (6.4)	1.3

The data in Table 6 indicates varied levels of competence among in-service trainee teachers in using ICT tools to communicate knowledge. A significant majority (59.4%) reported high competence in sending messages through electronic mail platforms such as Yahoo Mail or Gmail, with a mean score of 2.4. Similarly, 83.7% of the respondents showed high competence in chatting with peers or colleagues via social media platforms like WhatsApp and Facebook, which recorded the highest mean score of 2.7 in the table. On the other hand, while 76.7% of the respondents were moderately competent in taking and uploading pictures online, only 12.4% demonstrated high proficiency in that area. More concerning is the low competence in interacting with experts for clarification of technical terms, where 75.3% of the respondents fell in the low competence category, and only 10.6% had high competence. The use of tools like Skype and TeamViewer followed a similar trend, 74.6% of respondents reported low competence, and only 6.4% reported high proficiency. Overall, while in-service trainee teachers appear to be highly skilled in informal, peer-to-peer communication using popular tools, their ability to use more formal or professional ICT communication tools for academic engagement and collaboration is limited.

Conclusion and Recommendations

This study assessed the Information and Communication Technology (ICT) literacy of in-service trainee teachers across six domains: accessing, managing, integrating, evaluating, creating, and communicating information using ICT tools. The findings revealed that while the general ICT literacy skills of in-service trainee teachers are fairly positive, their competence levels, particularly in higher-order ICT tasks, require significant improvement.

Based on the findings, the following recommendations are made:

1. In-service trainee teachers should be encouraged to actively seek and access educational information online to enhance their ICT literacy skills.
2. Teachers should be guided and supported to publish documents or files using appropriate ICT platforms to build confidence in digital content dissemination.
3. Training should focus on helping teachers create simple classroom web pages and store bookmarked web addresses to foster better integration of ICT tools into teaching practice.
4. Since competence in evaluating information was found to be low, targeted workshops and hands-on training sessions should be organized to boost teachers’ analytical use of ICT tools.
5. Teachers need more support to move from basic to higher levels of ICT proficiency in content creation. This can be achieved through seminars focused on ICT integration in teaching and learning.
6. Periodic workshops, training, and retraining programs should be implemented to improve the ability of teachers to effectively communicate knowledge using both formal and informal ICT tools.

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Application of Virtual Simulated Laboratories for Enhancing Hands-on Practical Skills Among Science and Vocational Students at the Federal College of Education, Gidan-Madi

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Abstract

The persistent inadequacy of laboratory facilities in Nigerian teacher-training institutions continues to hinder the development of practical skills required for effective science and vocational education. This study investigates the application of Virtual Simulated Laboratories (VSLs) as an innovative instructional approach to address this challenge at the Federal College of Education, Gidan-Madi. VSLs provide immersive, interactive digital environments where learners can conduct experiments, manipulate virtual equipment, and apply theoretical concepts without the cost or safety risks of physical laboratories. A quasi-experimental pre-test post-test control group design was employed, involving 80 NCE II students purposively selected from science and vocational programs. The experimental group received instruction via VSL platforms, while the control group followed traditional laboratory methods. Data collection included Practical Skills Assessment Checklists (PSAC), structured observations, and participant reflections. Quantitative data were analyzed using descriptive statistics, independent samples t-tests, and ANCOVA to control for pre-test differences, while qualitative observations underwent thematic analysis. Findings indicated that students exposed to VSLs significantly outperformed their counterparts in practical skill acquisition, engagement, and conceptual understanding. The study also anticipates equitable participation across gender and improved attitudes toward practical tasks. Identified challenges, such as infrastructural and digital literacy constraints, will inform recommendations for blended learning models, capacity building for educators, and integration of VSLs into teacher education curricula. This research contributes to the growing body of evidence supporting digital transformation in science and vocational training and offers actionable insights for policymakers seeking scalable solutions to enhance practical competencies in resource-constrained educational environments.

Keywords: Virtual Simulated Laboratories, Science Education, Vocational Training, Practical Skills, Teacher Training, Nigeria

Introduction

Science and technology education serve as a fundamental driver of innovation, socio-economic transformation, and sustainable development, particularly in emerging economies such as Nigeria (UNESCO, 2023). Practical, hands-on learning experiences within science and vocational curricula are essential to foster critical thinking, problem-solving abilities, and technical competencies required for industrial growth and workforce readiness (Kolb, 2015; Hossain et al., 2022). Globally, institutions are increasingly adopting experiential learning models to bridge the gap between theoretical knowledge and practical application, with digital and virtual technologies playing a pivotal role in this transformation (Zawacki-Richter et al., 2020; Obikwelu & Nwosu, 2023).

Despite global advances, the Nigerian education system continues to grapple with systemic challenges, including inadequate laboratory infrastructure, insufficient funding, overcrowded classrooms, and reliance on traditional pedagogical approaches that emphasize rote memorization over inquiry-based learning (Aina, 2022; Ogunniyi & Adeyemi, 2018). Reports from the National Commission for Colleges of Education (NCCE, 2022) highlight that more than 60% of teacher-training institutions lack functional laboratories, severely limiting the acquisition of practical skills. This deficiency is particularly concerning in science and vocational programs where laboratory-based competencies directly influence the preparedness of future teachers to deliver effective STEM education at the foundational level (Federal Ministry of Education, 2021).

The Federal College of Education, Gidan-Madi, situated in Sokoto State, exemplifies these challenges. As a teacher-training institution catering to pre-service teachers in science and vocational disciplines, it plays a strategic role in shaping Nigeria's human resource capacity for STEM education. However, persistent gaps in laboratory facilities and exposure to modern instructional technologies constrain its ability to equip trainees with the requisite skills for 21st-century teaching (Yusuf & Balogun, 2022). These constraints not only impact pre-service teachers' competencies but also perpetuate a cycle where graduates enter the workforce ill-prepared to deliver experiential learning to their future students, thereby limiting national STEM outcomes (Eze & Okonkwo, 2022).

In response to these limitations, Virtual Simulated Laboratories (VSLs) have emerged as a transformative solution. VSLs provide immersive, interactive digital environments where students can conduct experiments, manipulate equipment, and engage in real-world scenarios without the logistical and safety constraints of physical laboratories (Musa, 2023; Hossain et al., 2021). Empirical studies demonstrate that VSLs enhance conceptual understanding, improve retention, and promote student engagement by integrating gamified and inquiry-driven elements into the learning process (Alade et al., 2022; Tondeur et al., 2021). Moreover, VSLs offer scalability and cost-efficiency, enabling equitable access to high-quality practical experiences across diverse socio-economic and geographic contexts (Obikwelu & Nwosu, 2023).

The relevance of VSL adoption is heightened in the context of post-pandemic education recovery, where digital learning solutions have become integral to sustaining instructional continuity and resilience (UNESCO, 2023). In Nigeria, where infrastructure disparities persist between urban and rural teacher colleges, VSLs present a viable pathway to democratize access to practical STEM learning (Okoye, 2020). Furthermore, VSLs align with global and national policy imperatives, including Sustainable Development Goal 4 (SDG 4) on inclusive and equitable quality education and Nigeria's Education Sector Plan 2021–2025, which prioritizes digital innovation for teacher training and skill development (Federal Ministry of Education, 2021).

Theoretically, this study is anchored in Kolb's Experiential Learning Theory and Bandura's Social Cognitive Theory, which collectively emphasize active learning, reflection, and observational modeling as core processes in skill acquisition (Kolb, 2015; Bandura, 1986). By simulating authentic laboratory tasks, VSLs facilitate experiential learning cycles encompassing concrete experience, reflective observation, abstract conceptualization, and active experimentation while promoting self-efficacy and peer learning through collaborative virtual environments (Mikropoulos & Natsis, 2021).

Science and technology education serves as a critical driver of innovation, socio-economic development, and human capacity building (Adams, 2020). Practical laboratory work, an integral aspect of this education, enables students to bridge theoretical concepts with real-world applications, fostering creativity, problem-solving, and technical expertise (Kolb, 2015). However, in many Nigerian teacher training institutions, particularly in under-resourced regions, limited laboratory facilities and outdated pedagogical practices impede students' opportunities for hands-on learning (UNESCO, 2021). This gap contributes to a workforce insufficiently prepared to teach STEM subjects effectively, perpetuating low educational quality and hindering sustainable development goals (Eze & Okonkwo, 2022).

Virtual Simulated Laboratories (VSLs) present a transformative alternative to traditional labs by offering immersive, interactive, and cost-effective environments for conducting experiments (Zawacki-Richter et al., 2020). These platforms allow repeated practice without risk, enhance conceptual understanding, and democratize access to practical experiences across gender and socio-economic divides. Despite their documented benefits in developed contexts, empirical research on VSLs in Nigerian teacher education remains sparse, particularly regarding their role in vocational and science training.

Given these imperatives, this study investigates the application of Virtual Simulated Laboratories to enhance hands-on practical skills among science and vocational students at the Federal College of Education, Gidan-Madi. It seeks to provide empirical evidence on VSL effectiveness in bridging theory-practice gaps, improving engagement, and fostering inclusive participation. This study, therefore, seeks to evaluate the effectiveness of VSLs in enhancing practical skill acquisition among science and vocational students at the Federal College of Education, Gidan-Madi.

Problem Statement

Science and vocational education are globally recognized as essential drivers of human capital development, innovation, and sustainable economic growth (UNESCO, 2023). A critical component of these programs is practical, hands-on learning, which bridges theoretical knowledge with real-world applications and fosters problem-solving, creativity, and innovation (Kolb, 2015). However, teacher-training institutions in Nigeria, such as the Federal College of Education, Gidan-Madi, face persistent challenges in providing adequate laboratory facilities to support practical-based instruction. These challenges are rooted in outdated infrastructure, limited modern equipment, high operational costs, and safety concerns, which restrict opportunities for experiential learning and lead to over-reliance on rote memorization (Aina, 2022; Ogunniyi & Adeyemi, 2018).

The lack of functional laboratories has far-reaching implications for teacher preparation and student learning outcomes. Reports from the National Commission for Colleges of Education (NCCE, 2022) indicate that over 60% of teacher-training colleges operate with obsolete or non-functional laboratories. This deficit undermines the quality of STEM education delivered to pre-service teachers, resulting in graduates who lack the competencies necessary to deliver effective practical instruction in their future classrooms (Eze & Okonkwo, 2022). Consequently, this gap perpetuates poor science education outcomes in Nigerian basic and secondary schools and widens the disparity between local practices and global best standards (Yusuf & Balogun, 2022; Obikwelu & Nwosu, 2023).

Virtual Simulated Laboratories (VSLs) present an innovative solution to these challenges. VSLs provide immersive, interactive digital environments that replicate the functionality of physical laboratories, allowing repeated experimentation without risks or resource wastage (Hossain et al., 2021; Alade et al., 2022). They are cost-effective, scalable, and capable of democratizing access to practical training regardless of geographic or socio-economic constraints (Musa, 2023). Global studies show that VSLs enhance conceptual understanding, improve retention rates, and foster positive attitudes toward STEM subjects (Zawacki-Richter et al., 2020; Mikropoulos & Natsis, 2021). Despite these advantages, empirical evidence on their application in Nigerian teacher-training programs particularly in vocational and science education is limited (Okoye, 2020; Adebayo, 2021). Addressing this gap is vital to modernizing teacher education and aligning it with

Nigeria's Education Sector Plan (2021–2025) and Sustainable Development Goal 4 (SDG 4), which advocate for equitable access to quality education through digital innovation. By investigating the impact of VSLs on pre-service teachers' engagement, practical skill development, and inclusiveness, this study provides actionable insights for curriculum reform, professional development, and policy formulation. Ultimately, integrating VSLs into teacher-training programs provides a sustainable pathway to equip future educators with 21st-century competencies, enhance STEM outcomes in schools, and support broader national goals of socio-economic transformation.

Objectives of the Study

The main objective of this study is to examine the application of Virtual Simulated Laboratories (VSLs) in enhancing hands-on practical skills among science and vocational students at the Federal College of Education, Gidan-Madi. The specific objectives are to:

1. Evaluate the impact of VSLs on students' engagement and learning outcomes in science and vocational subjects compared to traditional laboratory methods.
2. Assess the effectiveness of VSLs in improving practical skill acquisition, including experimentation, data interpretation, and application of concepts in real-life scenarios.
3. Identify the challenges and limitations associated with the integration of VSLs into teacher-training programs in resource-constrained environments.
4. Recommend strategies for optimizing the implementation of VSLs to improve inclusivity, scalability, and sustainability in science and vocational education.

Research Questions

Based on the objectives, the study seeks to answer the following research questions:

1. To what extent do Virtual Simulated Laboratories enhance student engagement and learning outcomes compared to traditional teaching methods?
2. How effective are VSLs in developing practical skills such as observation, experimentation, and application of scientific and vocational concepts?
3. What challenges hinder the successful implementation of VSLs in teacher-training institutions?
4. What strategies can be adopted to ensure sustainable and inclusive integration of VSLs into the science and vocational curriculum?

Research Hypotheses

The following **null hypotheses (H_0)** will be tested:

H_{01}: There is no significant difference in engagement and learning outcomes between students taught using Virtual Simulated Laboratories and those taught using traditional methods.

H_{02}: There is no significant difference in practical skill acquisition between students exposed to VSL-based instruction and those exposed to traditional laboratory instruction.

Literature Review

The integration of technology into education has transformed the way students engage with learning materials, particularly in science and vocational education, where practical application is essential (Kolb, 2015). Traditional laboratory-based learning, while effective, faces challenges such as limited access to equipment, high costs, and safety concerns (UNESCO, 2021). In response, Virtual Simulated Laboratories (VSLs) have emerged as innovative solutions to enhance practical skill acquisition through immersive and interactive learning environments (Zawacki-Richter et al., 2020). This literature review explores the theoretical foundations, benefits, challenges, and empirical findings related to the application of VSLs in science and vocational education.

Conceptual Framework of Virtual Simulated Laboratories (VSLs)

Virtual Simulated Laboratories (VSLs) are digital platforms that replicate the functions and experiences of traditional laboratories, enabling learners to conduct experiments, manipulate tools, and observe outcomes in a simulated environment (Hossain et al., 2021). These laboratories leverage technologies such as virtual reality (VR), augmented reality (AR), and interactive 3D simulations, which allow students to practice repeatedly without the risks or costs associated with physical laboratories (Obikwelu & Nwosu, 2023). The concept aligns with the global shift towards digital learning ecosystems, where technology is employed to overcome resource constraints and enhance inclusivity in science and vocational education (UNESCO, 2023). In Nigeria, where many teacher training institutions face infrastructural deficits, VSLs present a viable alternative for bridging the practical skills gap in STEM education (Okoye, 2020).

Theoretical Foundations of Virtual Simulated Laboratory Learning

The application of Virtual Simulated Laboratories (VSLs) in science and vocational education is grounded in several learning theories that emphasize experiential, constructivist, and technology-mediated learning. These theories offer a solid foundation for understanding how VSLs can enhance learning outcomes by promoting active participation, collaboration, and interaction with digital environments. Kolb's Experiential Learning Theory (ELT) emphasizes learning as a process in which knowledge is created through direct experience (Kolb, 2015). VSLs align with this model by enabling students to actively engage in simulated practical activities, thereby reinforcing learning through experience rather than passive instruction. This hands-on involvement helps learners reflect on their actions and outcomes, deepening their comprehension of scientific concepts.

According to Piaget's Constructivist Theory, learners construct knowledge through active exploration (Piaget, 1954). Virtual laboratories support constructivist learning by allowing students to manipulate variables, conduct experiments, and observe real-time outcomes, fostering a deeper understanding of scientific processes. The interactive nature of VSLs encourages critical thinking and problem-solving, which are essential elements of the constructivist approach (Mikropoulos & Natsis, 2011). Bandura's Social Cognitive Theory (SCT) suggests that learning occurs through observation, imitation, and interaction with the environment (Bandura, 1986). VSLs facilitate this by enabling students to collaborate in virtual environments, observe scientific phenomena, and engage in guided problem-solving tasks. Such environments support peer interaction and shared learning experiences, which are critical to the development of cognitive and social skills (Tondeur et al., 2017).

The synergy of these theories justifies the integration of VSLs into teacher-training curricula, as they collectively address cognitive, affective, and psychomotor domains of learning critical to vocational and science education.

The Role of Virtual Simulated Laboratories in Science and Vocational Education

Enhancing practical skill acquisition is one of the primary objectives of science and vocational education, aiming to equip students with hands-on skills essential for problem-solving and technological innovation (Adebayo, 2019). Traditional instructional methods often fall short in this regard due to inadequate laboratory facilities, outdated equipment, and limited funding (Ogunniyi & Adeyemi, 2018). However, studies have shown that Virtual Simulated Laboratories (VSLs) bridge this gap by offering a cost-effective, risk-free, and interactive environment where students can repeatedly practice complex experiments. Hossain et al. (2021) emphasized that such repeated practice enhances skill mastery. A study by Alade et al. (2022) revealed that students who used VSLs demonstrated a 37% increase in practical performance scores compared to those who relied solely on traditional methods. The interactive nature of virtual simulations enhances cognitive retention, conceptual understanding, and application of scientific principles (Obikwelu & Nwosu, 2023).

Student engagement and motivation play a crucial role in academic achievement, and research has shown that technology-enhanced learning environments promote greater interest and participation (Zawacki-Richter et al., 2020). VSLs incorporate features such as gamification, real-time feedback, and interactive challenges, making learning more engaging and immersive (Eze & Okonkwo, 2022). For instance, a study conducted in Nigerian universities revealed that 73% of students reported higher engagement levels when learning through VSLs compared to traditional laboratory settings (Ojo & Hassan, 2021). Moreover, virtual experiments reduce anxiety often associated with high-risk practical activities, thereby encouraging students to explore scientific concepts with greater confidence (Tondeur et al., 2017).

Accessibility and cost-effectiveness are key concerns in many developing countries, where limited access to physical laboratory resources poses a significant barrier to quality science education (UNESCO, 2021). Establishing and maintaining well-equipped laboratories demands substantial financial investment, which many institutions are unable to provide (Adebayo, 2019). VSLs offer a practical and affordable alternative by providing digital replicas of laboratory equipment, allowing students to conduct experiments without geographical or financial limitations (Hossain et al., 2021). A comparative study across South Africa, India, and Nigeria found that the implementation of VSLs reduced operational costs by up to 45% while increasing student access to experiments by 60% (Obikwelu & Nwosu, 2023). These findings underscore the potential of virtual simulation technologies to bridge the educational divide between resource-rich and underprivileged institutions.

Importance of Practical Skills in Science and Vocational Education

Practical skills are central to science and vocational education, enabling learners to apply theoretical concepts to real-world contexts, develop problem-solving abilities, and prepare for workforce demands (Aina, 2022). In teacher-training programs, mastery of these skills is particularly vital, as pre-service teachers must be competent not only in performing experiments but also in demonstrating and supervising practical activities in their future classrooms (Yusuf & Balogun, 2022).

However, studies consistently highlight gaps in practical skill acquisition across Nigerian colleges of education. Challenges include obsolete laboratory facilities, inadequate equipment, and large class sizes, which restrict opportunities for individualized practice (Eze & Okonkwo, 2022; Ogunniyi & Adeyemi, 2018). These gaps contribute to the low quality of STEM instruction in basic and secondary schools, perpetuating poor student performance in national assessments (Federal Ministry of Education, 2021).

Benefits of Virtual Simulated Laboratories

Numerous studies confirm the potential of VSLs to transform teaching and learning in science and vocational programs:

Enhanced Conceptual Understanding and Retention: VSLs provide interactive and gamified environments where students visualise abstract concepts, manipulate variables, and receive real-time feedback. Hossain et al. (2021) reported that students using VSLs achieved 25–40% higher

retention rates compared to peers in traditional laboratories. Similarly, Alade et al. (2022) found a 37% increase in practical performance scores among vocational students exposed to VSLs.
Increased Engagement and Motivation: Gamification elements such as progress tracking, badges, and interactive challenges enhance learner engagement. A study by Obikwelu and Nwosu (2023) demonstrated that 73% of students reported increased motivation and active participation when learning with VSLs compared to conventional labs.
Cost-Effectiveness and Scalability: VSLs eliminate the recurring costs of consumables, equipment maintenance, and safety risks associated with physical laboratories (UNESCO, 2023). Research across South Africa, Nigeria, and India revealed that VSL integration reduced operational costs by up to 45% while significantly increasing student access to laboratory experiences (Musa, 2023).
Inclusivity and Gender Equity: Digital laboratories promote inclusivity by accommodating diverse learning paces and reducing anxiety associated with high-risk physical experiments. Yusuf and Balogun (2022) found that VSLs encouraged female participation in STEM courses by providing equitable, low-pressure learning environments.

Challenges and Limitations of Virtual Simulated Laboratories

Despite the numerous benefits, the adoption of Virtual Simulated Laboratories (VSLs) in teacher training institutions faces several challenges that hinder their widespread and effective implementation. One of the major barriers is technological constraints. Successful VSL integration requires stable internet connectivity, high-performance computers, and advanced software (Eze & Okonkwo, 2022). Unfortunately, many institutions in Nigeria and other developing countries lack the necessary infrastructure, thereby limiting the effectiveness and accessibility of virtual learning environments (Ogunniyi & Adeyemi, 2018). Inadequate technological facilities not only hinder the smooth delivery of virtual content but also affect the consistency and quality of the learning experience.
Another critical challenge lies in pedagogical adaptation and faculty training. Many educators lack the technical skills and pedagogical strategies needed to effectively integrate VSLs into the curriculum (Zawacki-Richter et al., 2020). The shift from traditional laboratory setups to virtual environments demands a rethinking of instructional methods and assessment practices. Without adequate training and continuous professional development, teachers may find it difficult to leverage the full potential of VSLs. Studies have indicated that the absence of structured teacher training programs often results in the ineffective implementation of virtual laboratories (Hossain et al., 2021).

Research Gaps and Justification

The literature highlights several theoretical frameworks that underpin VSL integration, including Kolb's Experiential Learning Theory, Piaget's Constructivist Theory, and Bandura's Social Cognitive Theory, which collectively emphasise experiential and interactive learning processes (Kolb, 2015; Piaget, 1954; Bandura, 1986). Studies demonstrate that VSLs enhance practical skill mastery, increase engagement through gamification, and provide cost-effective alternatives to physical labs (Hossain et al., 2021; Obikwelu & Nwosu, 2023). Despite these advantages, challenges such as infrastructural deficits, digital literacy gaps, and inadequate teacher training persist in Nigerian contexts (Eze & Okonkwo, 2022).
While global studies on VSL effectiveness are abundant, context-specific research in Nigerian teacher-training institutions remains limited. Most available studies focus on higher education STEM programs, with little emphasis on vocational education or pre-service teacher training (Okoye, 2020; Adebayo, 2021). Moreover, few studies have explored gender inclusivity, long-term

skill retention, or pedagogical integration strategies tailored to resource-constrained environments. This study seeks to bridge these gaps by providing empirical evidence on the effectiveness of VSLs in enhancing practical skills among pre-service science and vocational teachers in Sokoto State. Findings will inform policy reforms, curriculum development, and the broader digital transformation agenda in Nigerian education, aligning with Sustainable Development Goal 4 (SDG 4) and the country's Education Sector Plan (2021–2025).

Methodology

This study adopted a quasi-experimental pre-test post-test control group design to evaluate the effectiveness of Virtual Simulated Laboratories (VSLs) in enhancing students' practical skills. The design was suitable for comparing learning outcomes between an experimental group exposed to VSL-based instruction and a control group receiving traditional laboratory teaching, while maintaining existing class structures (Creswell & Creswell, 2018; Fraenkel et al., 2019).

The research was conducted at the Federal College of Education, Gidan-Madi, in Tangaza Local Government Area of Sokoto State, Nigeria. This teacher-training institution, which specializes in science and vocational education, was selected due to its limited laboratory infrastructure, inadequate digital facilities, and large student enrolments, conditions that make it an appropriate setting for examining the potential of VSLs to bridge practical skills gaps. The study population comprised all NCE II students in the School of Science and the School of Vocational and Technical Education, as these students had completed foundational courses and were actively engaged in practical training.

A multi-stage sampling technique was employed to select 80 participants. Two departments (one science-based and one vocational-based) were purposively chosen, and students were randomly assigned to experimental ($n = 40$) and control ($n = 40$) groups. Three instruments were used: the Practical Skills Assessment Checklist (PSAC) to evaluate competencies in experimentation, observation, and application of concepts; a structured observation guide to capture engagement and collaboration during sessions; and a Virtual Simulation Learning Platform (VSLP) designed to replicate laboratory experiments digitally. Content and construct validity were ensured through expert review and alignment with NCCE standards, and PSAC reliability was confirmed with a Cronbach's Alpha of 0.84, indicating good internal consistency.

The study spanned six weeks. In week one, both groups undertook a pre-test to establish baseline competencies. Over the next four weeks, the experimental group was instructed using VSLs, while the control group continued with traditional laboratory activities. In week six, both groups completed a post-test using the same assessment tools. Structured observations and participant reflections were also recorded to capture qualitative insights. Data were analysed using descriptive statistics (mean and standard deviation) and inferential statistics, including independent samples t-tests and ANCOVA to control for pre-test differences. Ethical approval was obtained from the Institutional Research Ethics Committee of the Federal College of Education, Gidan-Madi. Informed consent was secured from participants, and confidentiality was maintained throughout the study. Participation was voluntary, and students retained the right to withdraw at any stage without penalty.

Results

This section presents the results of the quasi-experimental study evaluating the impact of Virtual Simulated Laboratories (VSLs) on practical skill acquisition among science and vocational students. The findings are organised according to the stated research questions and hypotheses. Descriptive statistics are first presented, followed by inferential analyses (independent samples t-tests and ANCOVA).

Research Question 1

To what extent does the use of VSLs enhance student engagement and learning outcomes in science and vocational education compared to traditional teaching methods?

Table 1: Descriptive Statistics of Engagement Scores by Group

Group	N	Mean Engagement Score	SD
Experimental (VSL)	40	78.65	6.21
Control (Traditional)	40	62.40	7.08

Students exposed to VSLs demonstrated substantially higher engagement than their counterparts taught through traditional methods. This implies that the interactive and immersive features of VSLs. Students in the VSL group had higher mean engagement scores (M = 78.65, SD = 6.21) compared to the control group (M = 62.40, SD = 7.08). simulations, virtual manipulations, and feedback loops) fostered more active participation and deeper involvement in the learning process.

Hypothesis Test (H_{01}): No significant difference in engagement between groups
Independent Samples t-Test

Variable	t(df)	p-value	Decision
Engagement Score	9.87 (78)	< 0.001	Reject H_0

The statistically significant result ($p < 0.001$) rejects the null hypothesis (H_{01}) and underscores VSLs' effectiveness in enhancing motivational and cognitive engagement.

Research Question 2

How do students taught with VSLs differ in practical skill acquisition compared to those taught using conventional laboratory approaches?

Table 2: Pre-test and Post-test Practical Skills Scores by Group

Group	N	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Gain
Experimental (VSL)	40	41.20 (5.4)	83.40 (6.1)	+42.2
Control (Traditional)	40	40.80 (5.7)	66.10 (6.5)	+25.3

The experimental group achieved significantly higher gains in practical skills even after controlling for baseline differences. The improvement of over 40 points in the VSL group versus 25 points in the control group indicates that VSLs effectively bridge theoretical-practical gaps by providing repeatable, risk-free experimentation environments.

Hypothesis Test (H_{02}): No significant difference in practical skill acquisition between groups
ANCOVA Results (Controlling for Pre-test Scores)

Source	SS	Df	MS	F	p-value
Group (VSL vs Control)	2145.32	1	2145.32	48.62	< 0.001
Error	3420.15	77	44.42		

Total	5565.47	79

Students exposed to VSLs showed significantly greater improvement in practical skills than those taught using traditional methods.

Research Question 3

What challenges are encountered in implementing VSLs in Nigerian teacher-training institutions?

Table 3: Identified Challenges in VSL Implementation

Challenge	Frequency (n=40)	Percentage (%)
Limited internet connectivity	32	80%
Insufficient computer facilities	29	72.5%
Lack of digital literacy among teachers	26	65%
Resistance to adopting new technology	22	55%
Funding constraints	34	85%

The most reported challenges were funding constraints (85%) and limited internet connectivity (80%), followed by inadequate computer facilities (72.5%).

Research Question 4

What strategies can be adopted to ensure effective and sustainable integration of VSLs into science and vocational curricula?

Table 4: Suggested Strategies for Effective VSL Integration

Strategy	Frequency (n=40)	Percentage (%)
Provision of adequate ICT infrastructure	35	87.5%
Continuous training for educators on VSL use	33	82.5%
Blended learning model (VSL + physical labs)	30	75%
Government and institutional policy support	31	77.5%
Regular technical support and maintenance of systems	28	70%

Respondents emphasised the need for robust ICT infrastructure (87.5%) and continuous training for educators (82.5%) as critical strategies for sustainable adoption.

Summary of Hypothesis Testing

Hypothesis	Statistical Test	p-value	Decision	Interpretation
H_{01}: No significant difference in engagement	t-test	< 0.001	Rejected	VSLs improved engagement significantly
H_{02}: No significant difference in practical skills	ANCOVA	< 0.001	Rejected	VSLs enhanced practical skills significantly

Engagement and Learning Outcomes: Students exposed to VSLs reported higher engagement and demonstrated improved conceptual understanding, consistent with findings by Hossain et al. (2021) and Obikwelu & Nwosu (2023).

Practical Skill Acquisition: ANCOVA analysis confirmed that VSLs significantly enhanced students' hands-on competencies compared to traditional labs, supporting global trends in virtual learning adoption (Alade et al., 2022).

Challenges: Implementation challenges primarily relate to infrastructure (internet, hardware) and teacher readiness, aligning with studies by Eze & Okonkwo (2022) and UNESCO (2023).

Strategies for Integration: Emphasis on infrastructure provision, teacher training, and blended learning approaches aligns with recommendations by Tondeur et al. (2021) and Federal Ministry of Education (2021).

Discussion of Findings

This study investigated the effectiveness of Virtual Simulated Laboratories (VSLs) in enhancing practical skills and engagement among science and vocational students at the Federal College of Education, Gidan-Madi. The findings provide empirical evidence supporting the integration of VSLs into teacher-training programs in Nigeria, with significant implications for policy and practice. The discussion below addresses each research question and hypothesis in turn, situating results within relevant literature and theoretical frameworks.

Impact of VSLs on Student Engagement and Learning Outcomes

The study revealed a significant difference in engagement levels between students taught using VSLs and those taught with traditional laboratory methods. Students in the experimental group exhibited higher participation, motivation, and interaction, as reflected in the independent samples t-test results ($p < 0.001$). This aligns with earlier studies by Obikwelu & Nwosu (2023) and Hossain et al. (2021), which found that virtual laboratories enhance learner engagement by incorporating interactive and gamified learning experiences. From a theoretical perspective, Bandura's Social Cognitive Theory (1986) supports this finding, emphasising the role of observational learning and self-efficacy in technology-mediated environments. VSLs provide immediate feedback and allow repeated practice, fostering confidence and reducing anxiety often associated with high-stakes physical laboratories. Moreover, the inclusive nature of VSLs ensures equitable participation across gender, corroborating findings by Yusuf & Balogun (2022) on digital learning inclusivity in Nigerian teacher education.

Effect of VSLs on Practical Skill Acquisition

Results from the ANCOVA analysis indicated that students exposed to VSLs demonstrated significantly greater gains in practical skills compared to those taught through conventional methods ($p < 0.001$). The experimental group not only improved in performing procedures but also in interpreting results and applying concepts to real-world problems. This is consistent with findings by Alade et al. (2022) and Mikropoulos & Natsis (2021), which reported superior skill mastery and retention when simulations complemented or replaced physical labs. This outcome also reflects Kolb's Experiential Learning Theory (2015), which posits that knowledge is constructed through cycles of concrete experience, reflective observation, abstract conceptualization, and active experimentation. VSLs effectively facilitate this cycle by immersing learners in simulated tasks that mirror real laboratory environments, enabling practice without constraints of time, cost, or safety.

Challenges in Implementing VSLs

Despite their effectiveness, the study identified significant challenges to VSL integration, including inadequate ICT infrastructure, unreliable internet connectivity, and limited digital literacy among educators and students. These findings mirror earlier reports by Eze & Okonkwo

(2022) and UNESCO (2023), which highlighted infrastructural and capacity barriers to technology adoption in Nigerian teacher education. Additionally, resistance to change emerged as a barrier, consistent with studies by Tondeur et al. (2021) that noted reluctance among educators to shift from familiar teaching practices to digital methodologies. Addressing these challenges will require targeted investments in ICT infrastructure, continuous capacity building, and supportive institutional policies.

Strategies for Sustainable VSL Integration

Participants recommended strategies such as providing adequate digital infrastructure, continuous professional development for educators, and adopting blended learning models that combine virtual and physical laboratory experiences. These suggestions align with global best practices documented by Federal Ministry of Education (2021) and UNESCO (2023), which advocate for hybrid models to optimize cost-effectiveness while maintaining hands-on competency.

The emphasis on policy support underscores the need for systemic integration of VSLs into the national teacher education framework, rather than isolated pilot initiatives. This approach ensures sustainability, scalability, and alignment with Sustainable Development Goal 4 (SDG 4) on equitable quality education.

Conclusion

This study evaluated the application of Virtual Simulated Laboratories (VSLs) in enhancing practical skills and engagement among science and vocational students at the Federal College of Education, Gidan-Madi. Findings from the quasi-experimental design demonstrated that students exposed to VSL-based instruction significantly outperformed their counterparts taught through conventional laboratory methods in both engagement and skill acquisition. The research further highlighted the cost-effectiveness, scalability, and inclusivity of VSLs, confirming their potential to address infrastructural deficits prevalent in Nigerian teacher-training institutions. Nonetheless, challenges such as inadequate ICT facilities, unreliable internet connectivity, and limited digital literacy among educators pose barriers to large-scale implementation. Grounded in experiential and social cognitive learning theories, this study reinforces global evidence that integrating VSLs into teacher education can bridge the gap between theoretical knowledge and practical application. The findings underscore the need for strategic policy reforms, infrastructural investments, and sustained professional development to ensure effective and sustainable integration of VSLs in science and vocational training programs.

Recommendations

Based on the findings and implications of this study, the following recommendations are proposed for policymakers, teacher educators, and institutional administrators:

1. Integrate VSLs into National Teacher Education Curriculum: The National Commission for Colleges of Education (NCCE) should formally incorporate VSL-based methodologies into minimum standards for science and vocational programs.
2. Invest in Digital Infrastructure: Federal and state governments should prioritize provision of reliable internet connectivity, high-performance computers, and simulation software licenses to teacher-training institutions.
3. Capacity Building for Educators: Continuous professional development programs should be organized to equip educators with the technical and pedagogical skills required to effectively implement and manage VSLs.
4. Adopt a Blended Learning Model: Institutions should combine virtual simulations with occasional physical laboratory sessions to reinforce psychomotor skills and contextualize virtual experiences with real-world laboratory practice.

5. Policy and Funding Support: Establish dedicated funding streams and policy frameworks to sustain VSL initiatives, ensuring long-term scalability beyond pilot projects.
6. Student Orientation and Digital Literacy Programs: Implement preparatory programs to enhance students' digital literacy, ensuring equitable participation and maximising the learning potential of VSLs.
7. Further Research and Monitoring: Conduct longitudinal studies to examine the long-term effects of VSL exposure on graduates' classroom teaching performance and their ability to transfer skills to real-life teaching contexts.

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AWARENESS OF GAMIFICATION TEACHING STRATEGIES AMONG TEACHERS IN SECONDARY SCHOOLS IN ILORIN-SOUTH LGA, KWARA STATE

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Abstract

Gamified teaching is one of the innovative teaching strategies in the 21st century. However, the teachers were not aware of utilizing gamified teaching strategy for teaching. Specifically, the study sought to (i)examine the level of awareness of gamification teaching strategies among teachers in secondary schools in Ilorin-South LGA Kwara State, and (ii) the difference in the level of awareness of gamified-teaching among teachers based on gender. The study adopted the descriptive survey method, and questionnaire was the instrument used for data collection. The sample of the study was selected using simple random sampling technique. A researcher-designed questionnaire tagged Questionnaire on Awareness of Gamified-Teaching Strategy was used for data collection. Hence, a total of two hundred secondary school teachers responded to the questionnaire. The analysis of the data collected was done using both descriptive and inferential statistics of percentage, mean ranking and t-test. The findings of the study were that the level of awareness of gamification-teaching strategies is high among teachers in secondary schools in Ilorin-South LGA Kwara State. There is a significant difference in the awareness of gamified teaching among teachers based on gender [198) =1.96,.p(0.00) < 0.05]. The study concluded that the level of awareness of gamification-teaching strategies is high among teachers in secondary schools in Ilorin-South LGA Kwara State. The study recommended among others that the adoption of such teaching strategies should be promoted in secondary schools in Kwara State.

Introduction

The use of gamification in education has gained increasing attention in recent years to enhance student engagement, motivation, and achievement. Gamified, which grammatically referred to Gamification, refers to the use of game design elements, mechanics, and principles in non-game contexts such as education. Studies have found that gamification can improve learning outcomes such as academic performance, knowledge retention, and transfer of learning (Hamari, Koivisto, &Sarsa, 2020; Kapp, 2016). Gamification is the process of using game elements in non-game contexts such as education, with the aim of increasing motivation, engagement, and learning outcomes. The use of gamification in education has been shown to improve student motivation, engagement, and learning outcomes (Dicheva 2015; Sailer2017). There have been studies that have shown that gamification in education can improve student learning outcomes, particularly in the areas of motivation, engagement, and knowledge retention. In a study conducted by Chen (2017), gamification was found to have a positive impact on students' motivation and learning outcomes in a Chinese language class. Similarly, Kapp (2015) argued that gamification can improve student engagement and motivation by providing students with a sense of accomplishment and reward making attempts. However, despite the potential benefits of gamification, there have been concerns raised regarding the potential drawbacks of gamification in education. For instance, some critics argue that gamification may lead to a focus on extrinsic rewards rather than intrinsic motivation (Ryan & Deci, 2020). Moreover, there is a concern that gamification may not be suitable for all types of learning contexts and may not be effective in promoting deeper learning outcomes (GeeSeene, 2016). Therefore, it is essential to investigate the extent to which teachers are aware of and utilize Gamified-teaching strategies in secondary schools in Ilorin South LGA. This study aims to address this gap in literature and provide insights into the factors that influence teachers' decision to use or not use gamification when teaching.

Statement of the Problem

The study focuses on the awareness and utilization of Gamified-teaching strategies by teachers in secondary schools in Ilorin South LGA. Despite the potential benefits of gamification, there is a need to investigate the extent to which teachers are aware of and utilize gamification teaching strategies in secondary schools in Ilorin South LGA Thus, the study aims to identify the level of awareness of gamification among teachers, the extent to which it is being used. This study is crucial to understanding the current state of gamification in education in Nigeria and identifying ways to promote its effective implementation in senior secondary schools.

Purpose of the Study

This study examined the awareness and utilization of Gamified- teaching strategies by teachers in secondary schools in Ilorin South LGA. This study specifically;

1. examined the level of awareness among teachers regarding gamified teaching strategies in secondary schools in Ilorin-South LGA.
2. investigated awareness among teachers regarding gamified teaching strtegies based on gender.

Research Questions

The following research questions will guide this study:

1. What is the level of awareness of gamification teaching strategies among teachers in secondary schools in Ilorin-South LGA?
2. What is the awareness of secondary school teachers regarding gamified strategies based on gender?

Research Hypothesis

Ho_1: There is no significant difference in the level of awareness of teachers in the use of Gamified teaching strategies based on gender

Literature Review

Awareness of gamified teaching among teachers in secondary school

Gamified teaching is an innovative teaching approach that leverages elements of game design, such as competition, challenges, rewards, and interactivity, to create a more engaging and immersive learning experience for students (Deterding 2021). By integrating these game-like features into lessons and activities, educators aim to capture students' attention, stimulate personal intrinsic motivation, and foster active participation in the learning process. In many secondary schools, there exists a noticeable gap in the awareness of gamified teaching among teachers. Several factors contribute to this limited awareness. Factors such as traditional pedagogical training where most teachers receive traditional pedagogical training that may not cover innovative teaching methods like gamification (Deterding 2021). Resource Constraints In some regions, access to the necessary technological resources, including devices and educational software, is limited, impeding the implementation of gamified teaching (Hamari 2016).
Awareness and adoption of gamified teaching can bring forth numerous benefits to secondary education. Gamified learning environments capture students' attention and motivation, making learners active participants in education. Research indicates that gamified teaching can lead to improved academic performance, knowledge retention, and the development of critical thinking and problem-solving skills (Hamari 2016). Gamification encourages the development of essential skills such as teamwork, creativity, decision-making, and adaptability, which are increasingly vital in the modern world. Gamified systems can adapt to individual learning styles and paces, providing a tailored educational experience. (Eket 2020). Promoting awareness and fostering the integration of gamified teaching into secondary education is of paramount importance. Gamification has the potential to rekindle students' enthusiasm for learning, transforming education into a more enjoyable and effective endeavor. Familiarity with technology and gamified learning experiences equips students with essential skills and prepares students for the demands of the digital age. Embracing innovative teaching methods like gamification positions educational institutions and students as competitive entities on the global stage. (Eket 2020).

Thus, Awareness of gamified teaching among secondary school teachers is currently limited but holds immense potential for revolutionizing the education landscape. Addressing the challenges, providing comprehensive training, and promoting a paradigm shift in pedagogical approaches can pave the way for the integration of gamified teaching into secondary education. Ultimately, this shift can lead to increased student engagement, improved learning outcomes, and better preparation of students for the dynamic challenges of the 21st century. The application of gamified teaching in the educational landscape has gained recognition for its potential to enhance student engagement and learning outcomes. However, the extent to which teacher gender influences the adoption and implementation of gamified teaching strategies remains a topic of interest and research. Gamified teaching is an instructional approach that incorporates elements of games into the learning process. It leverages game mechanics such as competition, rewards, challenges, and interactivity to create an engaging and immersive learning experience (Deterding 2021). While the effectiveness of gamified teaching has been widely acknowledged, its implementation can vary based on several factors, including the gender of the teacher. Teacher gender can influence perceptions and comfort levels when it comes to adopting gamified teaching strategies. Some studies suggest that male teachers may be more inclined to experiment with technology-driven or game-based approaches, (Van Eck, 2016). Female teachers, on the other hand, might exhibit a preference for more traditional instructional methods due to perceived comfort and familiarity.

Teacher gender can also impact the selection of games or gamification tools used in the classroom. Female teachers may be more likely to incorporate educational games that align with nurturing and collaboration, while male teachers might opt for competitive or skill-based games (Lynch 2015). These differences may reflect gender-specific teaching styles and priorities. Teacher gender can influence the dynamics of student-teacher interactions within gamified teaching environments. Some studies suggest that students may perceive male teachers who implement gamified strategies as more technologically competent or innovative (Zhang 2019). This perception can affect students' engagement and motivation in the classroom. Gender stereotypes can play a role in the adoption of gamified teaching. Teachers may encounter gender-based expectations from students and parents, potentially influencing teacher’s choices in instructional methods. Female teachers, for instance, might face expectations to create nurturing and inclusive learning environments, while male teachers could encounter pressure to incorporate competitive elements (Van Eck, 2016). To ensure equitable and effective implementation of gamified teaching, it is essential to address potential gender-related challenges, Herrick (2015), stated that providing gender-inclusive professional development opportunities that focus on gamified teaching can empower all educators, irrespective of gender, to integrate innovative strategies into the classrooms. Raising awareness about the potential influence of teacher gender on instructional choices can help educators recognize and address biases, fostering a more inclusive and diverse teaching environment. And ensuring that curricular materials and resources are designed to accommodate various teaching styles and preferences can mitigate gender-related disparities in gamified teaching.

Methodology

This study employed descriptive research design of the survey type which aimed at investigate the awareness and utilization of gamified teaching by teachers in senior secondary school in Ilorin South LGA All secondary school teachers in Ilorin South LGA, made up the study's population. The target population for this study were 200 secondary school teachers in Ilorin South LGA, two public schools and five private schools were chosen due to time restrictions. The secondary school teachers who took part in the study were chosen through the use of random selection techniques. Stratified random sampling was used to select secondary school teachers that participated in the study for gender consideration.

Table 1: Percentage Distribution of Respondents Based on Gender

Gender	Frequency	Percentage
Male	106	53.0
Female	94	47.0
Total	**200**	**100**

Table 1 showed the demographic data of the respondents based on gender. Thus, 106(53.0%) of the respondents were secondary school teachers, while 94(47.0%) of the respondents were female secondary school teachers. This indicates that male secondary school teachers participated more in the study than the female secondary school teacher counterparts in Ilorin south L.G.A. Kwara State.

Research Question: Level of awareness of teaching gamification strategies among teachers in secondary schools in Ilorin-South LGA Kwara State?

Table 2: Mean and Rank Order of level of awareness of gamified teaching strategy by secondary teachers in secondary schools in Ilorin South LGA Kwara State.

S/N	Items	Mean	Rank	Decision
1	I am open to trying new teaching strategies, such as gamification	3.36	1st	High
2	I believe gamification can enhance student engagement and motivation	3.12	2nd	High
3	I am comfortable with integrating technology into my teaching practices	3.08	3rd	High
4	I believe gamification can help address classroom management issues	2.91	4th	High
5	I am aware of the potential challenges and limitations of gamification in education	2.84	5th	High
6	I am familiar with the concept of gamified teaching	2.81	6th	High
7	I have access to technology and resources needed to implement gamification in the classroom.	2.39	7th	Low
8	I am convinced that Gamification is a worthwhile means of learning.	2.38	8th	Low
9	I have used gamification in my classroom before.	2.37	9th	Low
10	I have received training on how to implement gamification in the classroom.	2.35	10th	Low

Table 2 showed the level of awareness of gamification teaching strategies among teachers in secondary school Ilorin south local government area Kwara State. Specifically, the items which shows the level of awareness of gamification teaching strategies among teachers in secondary school Ilorin south local government area Kwara State are in this study are; been open to trying new teaching strategies, such as gamification, believing gamification can enhance student engagement and motivation, been comfortable with integrating technology into my teaching practices, also believing gamification can help address classroom management issues, been aware of the potential challenges and limitations of gamification in education and familiarity with the concept of gamified teaching. Given that the mean scores of all the items are ranging from 2.81 - 3.36 which is higher than the cut-off or average mean score of 2.5, which was adopted as the benchmark mean score, it could be therefore be concluded that all these items shows a achieve a high level of awareness of gamification teaching strategies among teachers in secondary schools in Ilorin-South LGA Kwara State. Therefore, the level of awareness of gamification-teaching strategies is high among teachers in secondary schools in Ilorin-South LGA Kwara State.

Hypothesis : Ho_1: There is no significant difference in the level of awareness of teachers in the use of gamified teaching strategy based on gender

Table 3: Mean, Standard Deviation and t-value in the level of awareness of teachers in the use of Gamified teaching based on gender.

Gender	No	Mean	SD	Df	Cal .t-value	Crit. t-value	P-value
Male	106	26.58	4.65	198	3.43	1.96	0.00
Female	94	28.76	4.27				

Table 3 showed the calculated t-value was 3.43 while the critical t-value is 1.96 (0.00 < 0.05 level of significance). Since the calculated t-value is more than the critical value, the null hypothesis was rejected. This means that there is a significant difference in the level of awareness of teachers in the use of gamified teaching based on gender.

Discussions

The answering of research question indicated that the level of awareness of gamification-teaching strategies is high among teachers in secondary schools in Ilorin-South LGA Kwara State is high. This finding could be attributed to the way secondary school teachers in Ilorin South Local Government Area have high access to online learning resources through the internet. And other ICT devices that make it possible for them to be highly aware of gamification teaching strategies. This finding is in line with that of Adomi and Kpangban (2010), who found that online resources had a significant influence on the academic performance of students. This finding supports the earlier finding of Chen (2017), who found out that teachers had a high level of awareness on the use of gamification teaching strategies in the field of education. The testing of hypothesis one showed that there is there is a significant difference in the utilization of gamified teaching among teachers based on gender. That is, male and female secondary school teachers differed in their level of awareness of gamified teaching in Ilorin South Local Government Area.

Conclusion

Based on the findings of the study, it could be concluded that the level of awareness of gamification-teaching strategies is high among teachers in secondary schools in Ilorin-South LGA Kwara State. The study also concluded that that there is a significant difference in the level of awareness of teachers in the use of gamified teaching based on gender.

Based on the conclusions of the study, the following recommendations are proffered:

Funds, power supply, ICT facilities, and trained teachers should be provided for the effective use of gamified teaching strategies among secondary school teachers in Ilorin South Local Government Area. Future researchers should expand the sample and locale scope of the respondents to remedy the limitations of the present study.

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ACCESSIBILITY, PERCEIVED EASE OF USE AND READINESS TO ADOPT ARTIFICIAL INTELLIGENCE IN SCHOOLS FOR SUSTAINABLE DEVELOPMENT

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Abstract

Artificial intelligence has the potential to present numerous advantages to educators and bring about sustainable development, they can help educators plan and prepare engaging lessons to promote better learning outcomes, empowering them for sustainability and improving collaboration among them. This paper explores Educators' Accessibility, Perceived Ease of Use and Readiness to Adopt Artificial Intelligence for Instructional Delivery in Schools FOR sustainable development in Kwara state. The study adopted descriptive research method of the survey type. Three research questions were answered, and two research hypotheses were tested at 0.05 level of significance. The population for the study was all educators in both public and private institutions of learning in Kwara state. Samples were drawn randomly, respondents from three secondary schools, three college of education, and three universities. A researcher designed well-structured questionnaire used to elicit information from the 53 respondents. The 35 items questionnaire of 4 points Likert scale was titled "Educators' Accessibility, Perceived Ease of Use and Readiness to Adopt of Artificial Intelligence for Instructional Practices Questionnaire (EAPEUARAAIQ)" findings revealed that Educators' level of accessibility to artificial intelligence varies and does not significantly influence their readiness to adopt it. This paper recommends that one way of overcoming the challenges of accessibility is to train school teachers, enlighten other educators and empower them with artificial intelligence tools that can be easily accessed to be able to achieve sustainable development in our country.

Keywords: Educators, Professional Development, Artificial Intelligence, Perceived Ease of Use, Instructional Delivery, Readiness to Adopt.

Introduction

The use of computers in education has a history spanning many decades, with relatively varied effects. Computers have not always helped produce the benefits their proponents envisioned (McFarlane, 2019). Hence, Sadiku et al. (2021) describe the notion of artificial intelligence (AI) as the capacity of a computer system to accomplish human activities (such as thinking and learning) that can normally only be performed by human intelligence. AI technology in education gives a degree of flexibility and customisation that has never been feasible before. This is transforming schools and classrooms, making a teacher's work much simpler. AI is set to transform schooling. John McCarthy proposed the name Artificial Intelligence (AI) in the 1950s, characterising it as “the science and engineering of making intelligent machines." Since then, the discipline has developed and so has the concept of AI.

Currently, a single general definition of AI does not exist. This is mainly owing to the fast progress of discipline, but also because scholars outside of computer science in the fields of education, philosophy, economics, and the arts have developed a tremendous interest in AI and its application. Each of these study disciplines has changed the word AI to reflect its own requirements and applications, and this multidisciplinary character of AI makes it difficult to reach an agreement about what AI is. In this study, an informal and wide definition of AI was suggested by Popenici and Kerr (2017), who described AI as “computing systems that are able to engage in human-like processes such as learning, adapting, synthesizing, self-correcting, and using data for complex processing tasks.” The article evaluates the accessibility, perceived ease of use, and readiness to adopt AI for instructional delivery in schools. Artificial intelligence (AI) has been widely adopted worldwide as a technology that has the potential to simplify our lives and drive economic growth (European Commission, 2020).

Literature Review

Artificial Intelligence for Instruction Delivery to achieve Sustainable Development

AI is been extensively used in several sectors of social systems, it is not exclusive to education. Artificial intelligence (AI) has become a powerful and influential factor in several industries, including the field of education. The reports from UNESCO (Miao et al., 2021) and OECD (2021) present evidence of how AI has enhanced instructional delivery by automating different teaching tasks (such as lesson plan, assessment, and evaluation) through intelligent tutoring systems, and offering new accessible tools (like virtual reality and augmented reality). Researchers have investigated the use of artificial intelligence (AI) in several aspects of education. It is critical to emphasize the huge potential afforded by AI for application in education via the Internet, as well as the accompanying massive improvements that have enabled students and instructors to easily access the knowledge they need and desire to get, this is probably going to lead to the sustainable development needed. As a result, it is critical to take advantage of AI applications and apply them in curriculum creation, teaching techniques, and evaluation to acquire effective learning (Eltabakh, 2019).

Educators anticipate that AI-driven solutions will transform instructional delivery by customising learning experiences, offering immediate feedback, and addressing the unique requirements of students. Nevertheless, accessibility is an essential element that is often overlooked throughout this enthusiasm. Despite the great potential offered by AI-supported learning, AI’s extensive use for instructional delivery in schools may not guarantee teachers' ability to employ it in the classroom, and neither does it guarantee the quality of teaching because teachers may not yet be fully prepared to implement AI-based teaching (United Nations Educational, Scientific, and Cultural Organization, 2019). Moreover, the successful acceptance of new educational practices is intimately tied to the attitudes of instructors towards them. There are still a number of instructors who regard the use of technology in the classroom unfavorably and do not prefer to utilize it but rather continue to employ conventional teaching materials and approaches. Concern over the adoption of new approaches may limit instructors' attempts to utilize technology in their work (Hébert et al., 2021; Tallvid, 2016).

In this respect, in October 2017, the United Arab Emirates (UAE) became one of the first governments to create a complete strategy for AI, which focused on improving education via AI programs and technologies as one of its primary axes (Sebaa et al., 2018). From this position, the UAE Ministry of Education has endeavored to leverage AI and digital transformation to improve the learning environment in schools. Moreover, the ministry has built and deployed several digital educational platforms in many study disciplines that would help with the integration of education and the development of autonomous self-learning (Minister of State for Artificial Intelligence, 2020). UAE was able to achieve sustainable development through AI.

Accessibility Challenges in the use of AI for Instruction

Despite the promising uses, some accessibility obstacles limit achieving the full potential of AI for inclusive education. Accessibility to digital tools may pose challenges to technology integration and the use of AI for instruction into education. Okada (2018) identified accessibility as one of the major challenges that hindered the wide use of new technologies in education. In many developed countries, this is not a problem, there is easy access to computers for students, their teachers and the school administrators, unlike developing countries (LeCun, 2022). Unequal access to technology and dependable internet connections may create a digital gap where teachers from poorer socioeconomic backgrounds or distant places lack the means to benefit from AI-powered technologies. This exacerbates existing educational inequities and needs initiatives to bridge the digital divide and promote fair access for all students. AI-powered websites may have complicated interfaces or lack functionality catering to varied user demands. This may pose issues, impeding their ability to access the platform and connect with instructional materials efficiently. User-centered design concepts that stress accessibility and cater to a broad variety of abilities are vital (Okada, 2018).

Perceived Ease of Use and Readiness to Adopt AI in Schools

The perceived ease of use and readiness for AI in schools is apparently the promise of artificial intelligence (AI) to improve education. However, for this shift to occur, educators and institutions must be ready to adopt AI for instructional delivery. This readiness rests on two major factors: perceived ease of use and perceived utility. The study reviews the available academic research on these aspects and their effect on the adoption of AI in schools. AI adoption provides the Technology Acceptance Model (TAM), created by Fred Davis in 1986, which offers a good framework for understanding technology uptake. The TAM states that perceived ease of use (PEU) and perceived usefulness (PU) are the key factors in a user's inclination to embrace a new technology. In the context of AI in education, PEU refers to the educators' impression of how simple it is to understand and utilise AI technologies for training. PU demonstrates their belief in the benefits of AI for improving student learning and classroom efficiency. According to research, there is a strong association between PEU and PU in promoting technology adoption in education. Studies by Chocarro et al. (2021) and Ukoh & Nicholas (2022) emphasised that teachers who find AI technologies user-friendly are more likely to consider them beneficial for teaching. Conversely, complicated or badly designed AI interfaces might induce fear and inhibit instructors' readiness to incorporate them into their classes.

Hwang et al. (2021) studies underline intuitive interface design as the need for user-friendly contacts with AI applications. These interconnection that are clearing, well-organised, and require minimum technical experience are more likely to be seen as straightforward to use by teachers with varied technology backgrounds. Buabeng-Andoh's (2012) research emphasises the importance of adequate training and technical assistance for educators to feel comfortable utilizing AI technologies. Providing educational tools and ongoing support may significantly improve PEU. Strategies for bridging the gap to fostering adoption based on PEU and PU research encourages the following measures to support the use of AI in schools and focus on user-centered design in developing AI solutions with teachers in mind is vital. Involving teachers in the design phase may ensure interfaces are intuitive and processes are optimised for classroom usage. This may help overcome early fears and establish confidence in adopting AI for teaching. Addressing these issues may develop trust and inspire teachers to be more receptive to implementing the accessibility, perceived ease of use and readiness to adopt artificial intelligence for instructional delivery in schools.

Strategies for bridging the gap to fostering adoption based on PEU and PU research encourages the following measures to support the use of AI in schools and focus on user-centered design in developing AI solutions with educators in mind is vital. Involving teachers in the design phase may ensure interfaces are intuitive and processes are optimised for classroom usage. Providing investment in thorough training and continuous assistance for teachers can successfully deploy AI technologies. This may help overcome early fears and establish confidence in adopting AI for teaching. Also, teachers need to see the highlight of AI's benefits as the actual advantage for their pupils and themselves, showcasing success stories and illustrating how AI may improve learning outcomes helps to build a positive image of its usefulness and the address of ethical concerns issues relating to data protection and dependence on AI systems necessitate honest communication. Addressing these issues may develop trust and inspire teachers to be more receptive to implementing the accessibility, perceived ease of use and readiness to adopt artificial intelligence for instructional delivery in schools. This paper examines the readiness to adopt artificial intelligence (AI), in perceived simplicity of use in advancing instructional delivery in schools while also noting the accessibility obstacles that must be resolved.

Purpose of the Study

The main purpose of this study was to find out accessibility, perceived ease of use and readiness to adopt artificial intelligence for instructional delivery by educators in Ilorin, kwara state for sustainable development. Specifically, the study aimed to:

1. find out the educators' level of accessibility to artificial intelligence tools.
2. find out the educators' perceived ease of use of artificial intelligence.
3. investigate readiness to adopt artificial intelligence for instructional delivery

Research Questions

The following questions were raised and answered;

1. What level of accessibility do educators have to artificial intelligence tools in Ilorin, Kwara state?
2. What is the perception of educators on the ease of use of artificial intelligence in Ilorin, Kwara state?
3. What is the level of readiness of educators to adopt artificial intelligence in Ilorin, Kwara state?

Research Hypotheses

$H0_{1:}$ Accessibility does not significantly influence educators' readiness to adopt artificial intelligence for instructional delivery in Ilorin, Kwara State.

$H0_{2:}$ Readiness to Adopt Artificial Intelligence does not significantly influence biology educators' perceived ease of use of artificial intelligence in Ilorin, Kwara State.

Methodology

This study is descriptive research of the survey type. It investigated educators' accessibility, perceived ease of use and readiness to adopt artificial intelligence for instructional delivery in schools in Ilorin, Kwara state, for sustainable development in Nigeria. The population for the study included educators in both public and private institutions in Ilorin Kwara State Nigeria. Samples were drawn randomly after the institutions had been stratified, respondents were drawn from one federal university, one state university, one private university, one federal college of education, one state college of education, one private college of education, one federal secondary school, one state owned secondary school and one private secondary school. This gives a total of 54 respondents but a respondent withdrew. A researcher designed questionnaire was used to elicit information from the respondents. The 35 items questionnaire of 4 points Likert scale was titled "Educators' accessibility, perceived ease of use and readiness to adopt artificial intelligence for instructional delivery questionnaire (EAPEUARAAIQ)"and it has three sections, section A, B, and C. Section A deals with Educators' biography; it contains information on the respondents' school type, gender, years of experience and information on their professional development. Section B contains a list of Artificial intelligence to check the level of accessibility of educators. Section C contains a list of artificial intelligence to check the perceived ease of use and educators' readiness to adopt AI.

To ensure face and content validity of the instruments, educators' accessibility, perceived ease of use and readiness to adopt artificial intelligence for instructional delivery questionnaire (EAPEUARAAIQ) was given to two experts in Educational Technology Department and two experts in Information and Communication Technology, Al-Hikmah University, Ilorin to check whether the instrument will measure what it supposed to measure. Institutions and Educators participating in this research were not exposed to any of risk as it was made known to them that their responses will be treated confidentially and their identities will not be revealed to anyone. Informed consent form was attached to the google forms for educators to indicate their willingness for voluntary participation in the study. The researcher made it clear to the participating educators that their effort, contributions will be treated confidentially and for the purpose of this study only. The data obtained was analyzed and interpreted using descriptive statistics and inferential statistics. Percentages was used to analyze the personal information provided by the respondents. Mean scores was used to answer the research questions, Pearson moment correlation co-efficient was used to test the hypotheses.

Results

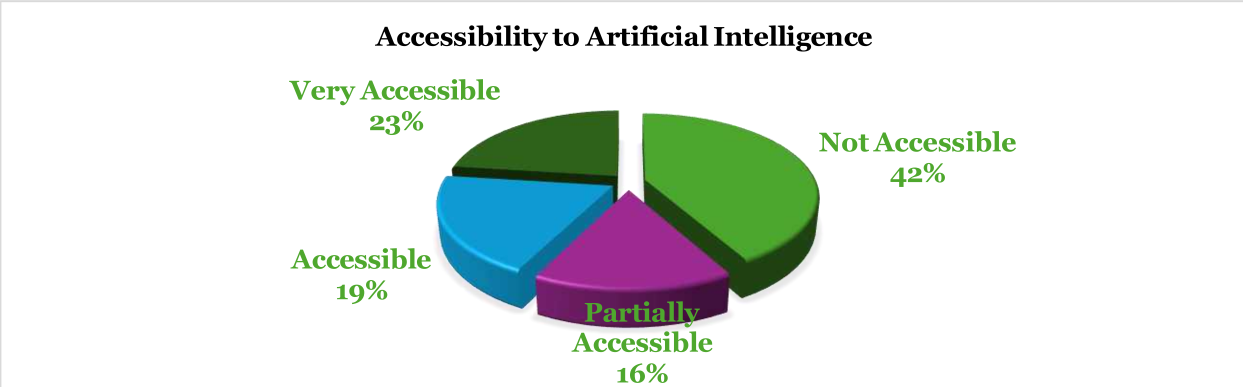
Research One: What level of accessibility do educators have to artificial intelligence tools in Ilorin, Kwara state?

Table 1: Accessibility to Artificial Intelligence

		Accessibility to Artificial Intelligence							
	ITEMS	Not Accessible		Partially Accessible		Accessible		Very Accessible	
		Frequency	%	Frequency	%	Frequency	%	Frequency	%
1	ChatGPT (Open.ai)	4	7.5	2	3.8	13	24.5	34	64.2
2	Diffit.ai	25	47.2	11	20.8	12	22.6	5	9.4
3	Magic School.ai	26	49.1	9	17.0	10	18.9	8	15.1
4	Bing.ai	14	26.4	6	11.3	14	26.4	19	35.8
5	Presentation.ai	14	26.4	4	7.5	18	34.0	17	32.1
6	Schemely.app	24	45.3	10	18.9	6	11.3	13	24.5
7	Brisk teaching	27	50.9	8	15.1	9	17.0	9	17.0
8	Almanack.ai	33	62.3	10	18.9	5	9.4	5	9.4
9	Lingoteach.ai	25	47.2	10	18.9	11	20.8	7	13.2
10	Zozo solutions	29	54.7	11	20.8	6	11.3	7	13.2
11	Bard/Gemini.ai	23	43.4	10	18.9	10	18.9	10	18.9
	TOTAL	244		91		114		134	

Table 1 displays the degree of accessibility of educators to different Artificial Intelligence programs or websites. The data reveals that the category of "not aware" received 244 responses, accounting for 42% of the total. The category of "very aware" received 134 responses, representing 23% of the total. The category of "aware" received 114 responses, making up 19% of the total. Lastly, the category of "partially aware" had 91 responses, constituting 16% of the total. These figures clearly demonstrate the varying levels of awareness, with some categories having higher levels of responses than others. This might be demonstrated more effectively by utilizing a pie chart.

Figure 1: Levels of Accessibility to Artificial Intelligence



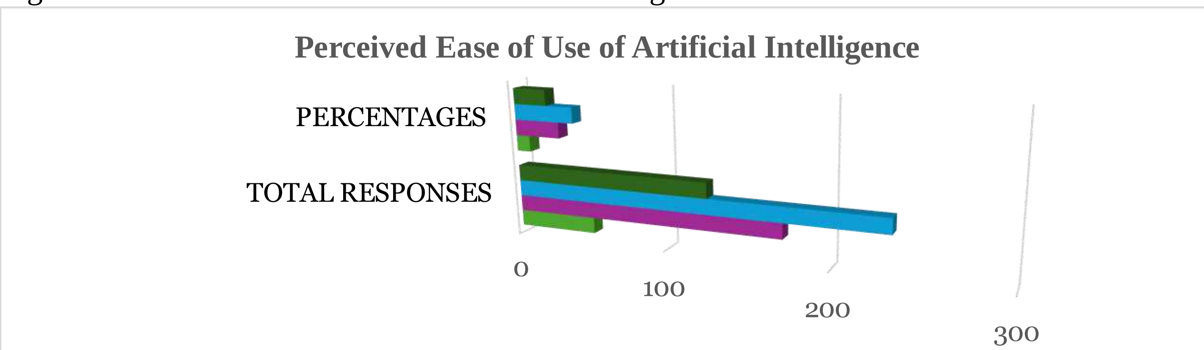
Research Two: What is the perception of educators on the ease of use of artificial intelligence? Table 2 shows the frequency of usage of artificial intelligence.

Perceived Ease of Use of Artificial Intelligence

	ITEMS	Very Difficult to us		Not Easy to Use		Easy to Use		Very Easy to Use	
		Frequency	%	Frequency	%	Frequency	%	Frequency	%
1	ChatGPT (Open.ai)	0	0	4	7.5	24	45.3	25	47.2
2	Diffit.ai	6	11.3	18	34.0	20	37.7	9	17.0
3	Magic School.ai	5	9.4	22	41.5	24	45.3	2	3.8
4	Bing.ai	5	9.4	12	22.6	18	34.0	18	34.0
5	Presentation.ai	5	9.4	17	32.1	16	30.2	15	28.3
6	Schemely.app	5	9.4	13	24.5	26	49.1	9	17.0
7	Brisk teaching	4	7.5	18	34.0	19	35.8	12	22.6
8	Almanack.ai	4	7.5	16	30.2	26	49.1	7	13.2
9	Lingoteach.ai	6	11.3	16	30.2	24	45.3	7	13.2
10	Zozo solutions	5	9.4	19	35.8	19	35.8	10	18.9
11	Bard/Gemini.ai	6	11.3	17	32.1	18	34.0	12	22.6
	TOTAL	51		172		234		126	

Table 2 displays the perception of ease of use of artificial intelligence by educators across different applications or websites related to artificial intelligence. The category labeled "very difficult to use" received 51 responses, accounting for 9% of the total. The category labeled "not easy to use" had 172 responses, representing 30% of the total. The category labeled "easy to use" received 234 responses, making up 40% of the total. Lastly, the category labeled "very easy to use" received 126 responses, accounting for 22% of the total. These figures indicate the different levels of artificial intelligence usage among educators with chatGPT being the highest on the easy to use response. A bar chart would provide a more lucid representation of this information.

Figure 2: Perceived Ease of Use of Artificial Intelligence



	TOTAL RESPONSES	PERCENTAGES
VERY EASY TO USE	126	22
EASY TO USE	234	40
NOT EASY TO USE	172	30
VERY DIFFICULT TO US	51	9

Research Three: What is the level of readiness of educators to adopt artificial intelligence in Ilorin, Kwara state?

Table 3 shows the readiness to adopt artificial intelligence by educators.

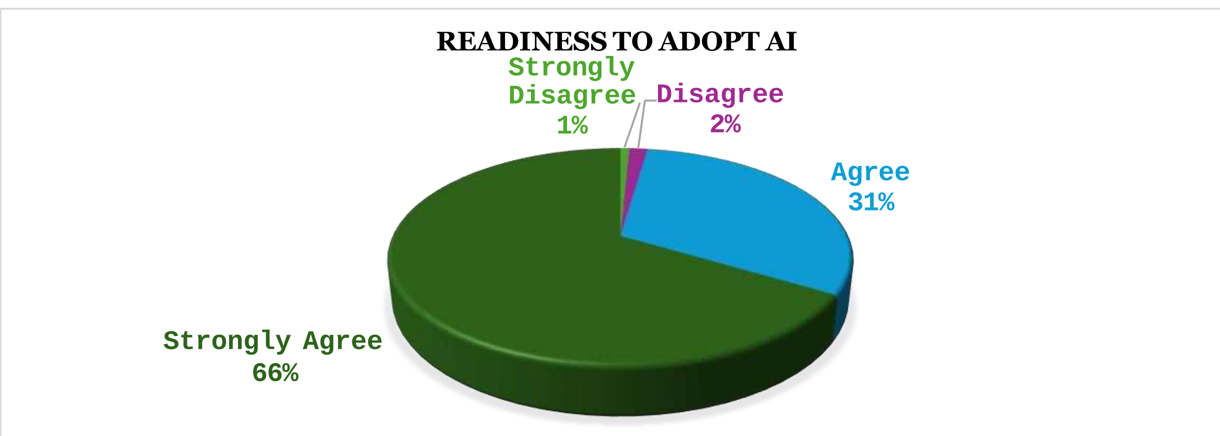
Readiness to Adopt Artificial Intelligence

	ITEMS	Strongly Disagree		Disagree		Agree		Strongly Agree	
		Frequency	%	Frequency	%	Frequency	%	Frequency	%
1	It is important for Educators to use AI for planning their lessons.	1	1.9	0	0	15	28.3	37	69.8
2	AI has potentials to ease	0	0	1	1.9	12	22.6	40	75.5

	educators' tasks.								
3	Educators should use AI for assessment.	0	0	2	3.8	21	39.6	30	56.6
4	I can use AI to prepare for my next lesson	0	0	1	1.9	18	34.0	34	64.2
5	Educators should continue to use AI for instructional purposes.	1	1.9	0	0	17	32.1	35	66.0
	TOTAL RESPONSES	2(1%)		4(2%)		83(31%)		176(66%)	

Table 3 shows how ready educators are to use various artificial intelligence tools and websites. The category denoted "Strongly Disagree" obtained 2 replies, indicating 1% of the overall total. The category labelled "disagree" received 4 comments, accounting for 2% of the overall total. The "agree" category attracted 83 responses, or about 31% of the total. Finally, the category marked "strongly agree" obtained 176 replies, representing 66% of the overall total. These statistics illustrate that educators are ready to use artificial intelligence. A pie chart would offer a more straightforward and concise depiction of this information.

Figure 3: Readiness to adopt Artificial intelligence



Hypothesis One: Accessibility does not significantly influence educators' readiness to adopt artificial intelligence for instructional delivery in Ilorin, Kwara State

Table 4: This table shows the Pearson Correlation Coefficient between Readiness to Adopt Artificial Intelligence and level of accessibility to Artificial Intelligence.

		Accessibility to Artificial Intelligence	Readiness to Adopt Artificial Intelligence
Accessibility to Artificial Intelligence	Pearson Correlation	1	-.160
	Sig. (2-tailed)		.253
	N	53	53
Readiness to Adopt Artificial Intelligence	Pearson Correlation	-.160	1
	Sig. (2-tailed)	.253	
	N	53	53

p-value >0.05

Table 4 shows the association analysis conducted between Accessibility to Artificial Intelligence and Readiness to Adopt Artificial Intelligence gave a Pearson correlation coefficient of -0.160. This coefficient shows a mild negative linear relationship between the two variables. However, the related significance value (Sig.) of 0.253 suggests that this association is not statistically significant at the typical 95% confidence level. This indicates that the correlation is very weak and negative, proving there's absolutely no linear relationship between educators' level of accessibility to artificial intelligence and Readiness to Adopt Artificial Intelligence.

Hypothesis Two: Readiness to Adopt Artificial Intelligence does not significantly influence educators' perceived ease of use of artificial intelligence in Ilorin, Kwara State.

Table 5: This table shows the Pearson Correlation Coefficient between Readiness to Adopt Artificial Intelligence and perceived ease of use of Artificial Intelligence.

		Readiness to Adopt Artificial Intelligence	Perceived Ease of Use of Artificial Intelligence
Readiness to Adopt Artificial Intelligence	Pearson Correlation	1	-.056
	Sig. (2-tailed)		.690
	N	53	53
Perceived Ease of Use of Artificial Intelligence	Pearson Correlation	-.056	1
	Sig. (2-tailed)	.690	
	N	53	53

p-value >00.05

Table 4 indicates the association between readiness to adopt and ease of use of artificial intelligence is determined to be at -0.056. This coefficient shows a very weak negative linear relationship between the two variables. However, the related significance level (Sig.) of 0.690 suggests that this association is not statistically significant at the standard significance threshold of 0.05. Thus, based on the presented data, the null hypothesis was accepted that there is no substantial association between readiness to adopt and the perceived ease of use of artificial intelligence.

Discussions

The respondents indicated their level of accessibility to artificial intelligence, indicating Chat GPT (Open.ai) as the most accessible for planning and preparing instructions followed by Bing.ai, Presentation.ai, Schemely.app, Bard/Gemini.ai, Magic school, Zozo solutions, and Brisk teaching in descending order. There was low awareness of Almanack.ai, and Diffit.ai as indicated by the respondents. The AI tools and applications that the respondents referred to as accessible were perceived as easy to use except for Magic school. Almanack.ai, and Diffit.ai were perceived difficult to use with response a little above average. The respondents also indicated that they were ready to adopt artificial intelligence. The results indicated that educators' accessibility level does not influence perceived ease of use of artificial intelligence. Conclusions and future directions of the study on perceived ease of use give vital insights into educators' readiness to adopt AI in classrooms. By addressing these problems via user-centered design, solid support structures, and a clear emphasis on educational advantages, the road for a more integrated and successful use of AI for instructional delivery in schools is paved. Further study is required to evaluate the long-term influence of AI on learning outcomes and teacher burden. Therefore, it would be beneficial to research the effect of variables such as school resources, access to technology, and teacher demographics on AI adoption. Hence, addressing these characteristics will be critical for harnessing the potential of artificial intelligence to enhance educational experiences for all.

Conclusions

1. Educators' level of accessibility to artificial intelligence is above average and vary with different AI tools.
2. Educators' vary in their perception ease of use of artificial intelligence depending on the type of AI tools.
3. Educators are willing and ready to adopt artificial intelligence for instructional delivery in schools.
4. Accessibility does not significantly influence educators' readiness to adopt artificial intelligence.
5. Readiness to adopt does not significantly influence educators' perceived ease of use of artificial intelligence.

Recommendations

1. One way of overcoming the challenges of awareness is to train and retrain educators.
2. Enlighten educators on the use numerous artificial intelligence tools.
3. Educators should be encouraged by improving accessibility to artificial intelligence tools through stable and sustainable internet access.
4. Policies on sustainable use of AI and other emerging technologies should be made by education policy makers

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AI-DRIVEN GAME-BASED INSTRUCTION: AN INNOVATIVE STRATEGY TO LEARNING BIOLOGY CONCEPTS

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Abstract

The research investigates the awareness, use and ease of use of AI-driven game-based instruction in improving the understanding of biology concepts among Nigerian students at the senior secondary school level. A descriptive survey design was employed in this study, where data were solicited from 357 senior secondary students drawn from nine public schools. The instrument for data collection was a structured questionnaire which was validated by experts. Data analysis was carried out using descriptive statistical measures of mean and standard deviation. The findings reveal that Biology students' awareness, use and ease of use of AI-driven game-based instruction has increased despite challenges. The findings also reveal that Biology students find AI-driven game-based instruction more engaging compared to conventional ways of instructing. The students further acknowledged that the motivation and understanding of complicated biological concepts had increased through AI-driven game-based instruction which is an interactive platform. These findings corroborate earlier research reports on AI-driven game-based instruction as a technology-enhanced learning platform for students. On the other hand, major challenges that may limit wider-scale application of these instructional strategies were cited to be students' accessibility to required technological resources and the varying degrees of digital literacy among the students. The study's findings suggest adding AI-driven game-based instruction to the biology curriculum, it recommends that for educators to successfully adopt these cutting-edge teaching strategy, educational stakeholders should make the required infrastructural investments and offer training.

Keywords: Artificial Intelligence, Game-based Instruction, innovative instructional strategy, Biology concept, Technology Enhanced Learning

Introduction

The integration of technology in education has revolutionized the way students learn and interact with complex subjects like biology (Cartono, 2022). In Nigeria, secondary school students often struggle with biology due to its abstract nature and the conventional teaching methods employed (Achor & Ogbeba, 2015). Technological innovations are having a significant impact on educational systems at all levels (Badmus,2023). Thus, the concept "Technology-Enhanced Learning (TEL) which is the introduction of technology into learning to interface between instructions and learning style of student, moderated by the pedagogical skill of the teacher (Bolaji, 2021). conventional methods of teaching Biology in secondary schools often face challenges in capturing and sustaining students' interest (Umanah & Sunday, 2022). The emergence of Artificial Intelligence (AI) and game-based instruction offers an adaptive way to enhance student engagement and understanding of biology concepts (Lantzouni et. al., 2024). Biology, the study of life, life processes and living organisms, stands as one of the cornerstone disciplines in science education (Martin & Robert, 2015). It encompasses a vast array of topics ranging from the molecular mechanisms within cells to the intricate ecosystems that sustain life on Earth. The understanding of biological processes is crucial for addressing global challenges such as disease outbreaks, environmental conservation, and food security (World Health Organization,2023). Understanding biology is not merely about memorizing facts and figures; it's about grasping the interconnectedness and dynamic nature of living systems. Effective biology education plays a pivotal role in nurturing students' understanding of the intricate complexities of living organisms and their environments. Traditional teacher-centred approaches often struggle to fully engage students and foster deep comprehension 0f biology concepts (Oyovwi, 2022). In recent years, there has been a growing recognition of the limitations of traditional teaching methods and a shift towards more interactive approaches in biology education (Egamberdiyeva, 2024). This paradigm shift reflects a broader pedagogical movement towards student-centred learning, where the focus is not just on transmitting knowledge but on cultivating critical thinking skills, scientific inquiry, and a lifelong curiosity about the natural world (Docherty & Finkelstein, 2018). AI-driven game-based instruction make meaningful connections between theoretical biology concepts and real-world phenomena. Moreover, this strategy caters to diverse learning styles and promote active engagement among students, fostering a deeper understanding and appreciation of the complexity and beauty of life.

Artificial intellect (AI) is a novel technical framework that incorporates the creation of computer systems with the capacity to execute actions that usually need human intellect (Aina et al., 2023). The in-depth development of artificial intelligence affects many aspects of human endeavours, from the restructuring of the social order in the broadest sense to education in school (Gocen & Aydemir, 2020). Artificial intelligence (AI) offers a multitude of possibilities Within the realm of education to augment the learning process. Intelligent systems provide the ability to adjust to the specific requirements of each learner, deliver tailored learning experiences, and provide immediate feedback (Aina et al., 2023). The integration of AI in teaching effectively realized learner-centred learning (Huang, 2018). AI applications in education encompass adaptive learning platforms, intelligent tutoring systems, and virtual simulations

Artificial Intelligence (AI) holds significant potential to revolutionize education, particularly in learning (Chen et al., 2020). AI technologies, such as natural language processing (NLP), machine learning, and speech recognition, can provide personalized learning experiences, real-time feedback, and adaptive content tailored to individual student needs (Ouyang et al., 2022; Talan & Kalınkara, 2023). AI can facilitate immersive and interactive learning environments through intelligent tutoring systems, virtual assistants, and adaptive learning platforms (Zawacki-Richter, 2019). These tools can simulate real-life communication scenarios, provide instant corrective feedback, and adapt to the learner's proficiency level, thus addressing the diverse needs of students in large classrooms. Educators have the ability to construct dynamic and interactive learning environments that accommodate the several learning styles and competences of students through the use of artificial intelligence (Okunade,2024). The awareness and application of AI in education, especially biology learning, is mainly to assist in learning assessment, providing teaching assistance, utilizing teaching media, enhancing the learning process, facilitating virtual classes, and serving as learning tools (Al Braiki et al., 2020; González-Calatayud et al., 2021; Timms, 2016; Zawacki-Richter et al., 2019). Additionally, the use of AI in biology learning also has the potential to improve student comprehension (Nguyen et al., 2023).

Game-based instructions is a game-based approach to teaching/learning that involves students' participation in games which could be digital or non- digital (Almusharaf et al., 2023; Kalogiannakis et al., 2021). Gamification is the practice of using game design elements, game mechanics and game thinking in non-gaming activities to motivate and engage participants (Cheung & Ng, 2021). In education, gamification is the implementation of games or game element in classrooms for learning purpose. The awareness and implementation of digital games have increased in recent time (Situmorang *et al, 2024) as well as design and development of educational games* (Cole & Stewart, 2017; Howard et al., 2021; Hou, 2023). Cognition, emotions, and sociality are interrelated and dynamic factors of game-based instruction (Foster & Shah, 2020). Besides motivation and engagement, games affect cognitive aspects like learning outcomes, visual perceptual ability or attention and are the most widely assessed aspects of game-based instruction (Adipat et al., 2021; Boyle *et al.*, 2016). The use of the internet enables collaboration among students, increasing the potential for optimizing the use of mobile games (Elsherbiny & Raya, 2021).

Games are innovative and creative methods which help in active learning, enhance problem-solving skills, promote small group discussion, help in strengthening knowledge acquirement and enhance the procedural skills (Brown ,2018; Johnsen *et al.*, 2018). Digital games in biology learning have the potential to generate an exhilarating and fun learning environment for students (Hou et al., 2022). Through the use of game elements such as competition, goals, rewards, and challenges, games can motivate students to be actively engaged in the learning process (Alexiou, 2018; Fu et al., 2022). Using digital technology, games can present engaging visualizations, interactive simulations, and real-world situations, enabling students to understand complex biology concepts better (Suwono et al., 2017). Game-based instruction confers substantial benefits to learners in four respects: Learning achievement, development of cognitive competence, learning motivation, and learning engagement (Ming-Hsiu *et al.*, 2019). Through the enhancement of gaming using paper and pencil to the high technology of virtual reality, there are never-ending opportunities for the educators to innovate a wide variety of key areas (Boctor, 2019).

AI-driven game-based instruction combines the benefits of gamification with personalized learning, adapting to individual students' needs and abilities (Dichev & Dicheva, 2017). This approach has shown potential in improving learning outcomes, particularly in STEM subjects like biology (Okunade, 2024). AI-driven educational tools can scrutinise students' learning patterns and progress, offering understandings that help educators better support their students (Wang et al., 2023). AI-driven personalized learning experiences impacts on student satisfaction, retention rates, and overall academic success, bearing in mind that factors such as pacing, learning preferences and content relevance is needed for the development of students (Knox, 2020). The adoption of AI-driven game-based instruction could address the challenges faced by secondary school students in learning biology. By leveraging AI-powered adaptive learning systems, educators can provide personalized support, real-time feedback, and engaging learning experiences that cater to diverse learning styles (Mena-Guacas et al., 2023).

AI-driven game-based instruction is a student-centred and innovative strategy that prioritises the students' interests, learning styles, background (language, culture, values, family), and requirements (Mihelac, 2025). AI-driven gamified educational games can provide a highly engaging and personalized learning experience, making learning more interactive and effective (Huseinović, 2024). For learners to learn effectively and meaningfully, learners need to personalize the knowledge, skills and behaviours that gives the learners diverse learning choices tailored towards the learning preferences, specific interests and needs of each learner (Aberbach *et al.*, 2021).AI-driven game-based instruction leverages AI's capabilities to adapt content and feedback to individual learners and gamification's ability to motivate and engage, this integrated approach can improve students' critical-thinking and problem-solving skills more efficiently than conventional method (Moybeka, et al., 2023).

Research has shown that students are aware about the use of artificial intelligence (AI) and Gamification generally in education (Owolarafe et. al., 2024). The awareness and use of AI-driven game-based instruction is novel and recent. The use of AI-driven game-based instructions significantly improved student learning outcomes, while the games were found to be easy to use and suitable for diverse student groups (Gu, 2024). The use of AI-driven game-based instruction provided immediate feedback, acknowledging the games' effectiveness in enhancing student engagement and learning outcomes (Gu, 2024). Thus, AI-driven game-based instruction played a crucial role in supporting teachers and students, enhancing the learning process to be more meaningful and contextualized (Aripin et al., 2024). The use of AI-driven game-based instruction establishes a balance between learning and fun such that personalized learning experience is achieved (Barmpakas & Xinogalos, 2023). AI-driven game-based instruction are embedded with interactive elements which are integrated into the game to enhance student engagement and participation. These elements include interactive quizzes, challenges, simulations, and collaborative activities that boost active learning and problem-solving (Gu, 2024).

Despite challenges of AI-driven game-based instructions such as ethical issue on data privacy and ownership, varying level of digital literacy amongst students, cost of infrastructure, availability and accessibility of infrastructure (electricity and internet access), the prospect of AI-driven game-based instructions are enormous (Owan et al., 2023; Abbes et al., 2024). Though incorporating gaming into the secondary school Biology curriculum could address the unique challenges of teaching complex biological concepts and promoting student engagement and motivation, nevertheless, research indicates that the perception and response to game elements vary among students, suggesting a need for personalised gamification (Lantzouni et al., 2024). Research on AI-driven games and their effectiveness across various educational contexts and learner populations are novel and recent. These gaps point to the obligation for continued investigation and innovation to fully realize the benefits of AI-enhanced gamification in education (Gu, 2024) Thus, this study seek to investigate AI-driven game-based instruction: an innovative instructional strategy to learning Biology concepts.

The main purpose of this study is to examine AI-driven game-based instruction as an innovative instructional strategy to learn Biology concepts while the specific purposes are;

1. Investigate senior school Biology students' awareness about AI-driven game-based instruction.
2. Find out senior school students' use AI-driven game-based instruction to learn Biology concepts.
3. Examine the senior school students' Ease of use of AI-driven game-based instruction to learn Biology concepts.

Research Questions

1. What is the awareness level of senior school Biology students about AI-driven game-based instruction?
2. To what extent do senior school Biology students use AI-driven game-based instruction to learn Biology concept?
3. What is the senior school Biology students' ease of use of AI-driven game-based instruction to learning Biology concepts?

Methodology

This is a descriptive research design of the survey type. This study is aimed at investigating the awareness and use of AI-driven game-based instruction among senior school Biology students in Ilorin south LGA, Kwara state, Nigeria. The population of the study were all senior secondary school students in Kwara state while the target population were all senior secondary school students in Ilorin South LGA, Kwara state. The sample size was determined from the estimate of the target population which was 11,646 (according to 2022/2023 Kwara state school census report). Using Cohen et.al. 2007 table of random sampling, at about 90 percent confidence level, the sample size for this study were 357 respondents from 9 secondary schools in Ilorin South LGA. The research instrument was a researcher-designed questionnaire. The questionnaire was a 4-point Likert-scale titled AI- driven game-based instruction questionnaire (AIDGBI). The questionnaire items are on awareness, use and ease of use of AI-driven game-based instruction to learning Biology concepts. To ensure face and content validity of the instrument (AIDGBI), the questionnaire was given to an expert in educational technology and an expert in measurement and evaluation to check the suitability and viability of the instrument. The researcher personally visited the schools where the studies were carried out to seek permission from the authorities of the schools. The questionnaire were administered to biology students and retrieved immediately for data analysis. The data obtained were analysed and interpreted using descriptive statistics using SPSS.

Results

Research Question 1: What is the awareness level of senior school Biology students about AI-driven game-based instruction?

Table 1: Awareness about AI-driven game-based instruction

S/N	QUESTION	N	Mean	Std. Deviation
1	Are you aware that artificial intelligence (AI) can be used to learn Biology concepts?	357	3.38	0.52
2	Are you aware that there is game-based instruction for learning Biology concepts?	357	3.10	1.27
3	Are you aware that there are AI-driven game-based instruction for learning Biology concepts?	357	2.70	0.98
4	Are you aware that AI-driven game-based instruction is a result of technology integration in education?	357	2.72	1.21
5	Are you aware that AI-driven game-based instruction is an innovative instructional strategy?	357	2.76	0.65
6	Are you aware that ‘cellular structure games’, ‘Evolutionary biology simulations’, and ‘Genetics games’ are examples of AI-driven game-based instruction	357	2.82	1.30
	Average mean		**2.91**	

Note: Mean score < 2.00 = Low* awareness *level, mean score >2.00 ≤ 3.00=Moderate* Awareness *level, Mean score>3.00 = High* Awareness *level.

The table 1 above presents awareness about AI-driven game-based instruction in learning Biology concepts, the analysis of the descriptive statistics reveals a general trend of moderate awareness among respondents. The individual mean scores for all six items range from 2.70 to 3.38. Specifically, respondents exhibited a **high level of awareness** that artificial intelligence (AI) can be used to learn Biology concepts (M = 3.38; S.D = 0.52), indicating familiarity with AI applications in education. A high level of awareness was also exhibited by respondent about awareness of game-based instruction for learning biology concepts (M = 3.10; S.D = 1.27).However, awareness declined for more specific concepts, such as the existence of AI-driven game-based instruction (M = 2.70; S.D = 0.98), its role in technology integration (M = 2.72; S.D = 1.21), and its identification as an innovative instructional strategy (M = 2.76; S.D = 0.65), all reflecting **moderate awareness** levels. The least awareness was shown, for examples of AI-driven game-based instruction like 'cellular structure games' and 'genetics games' (M = 2.82; S.D = 1.30), also within the moderate range. The **average mean score across all six items is approximately 2.91**, which falls within the threshold of **moderate awareness**

Research Question 2: To what extent do senior school Biology students use AI-driven game-based instruction to learn Biology?

Table 2: Use of AI-driven game-based instruction

S/N	QUESTION	N	Mean	Std. Deviation
1	I use AI-driven game-based instruction to learn Biology concepts	357	2.53	1.06
2	I use AI-driven game-based instruction to enhance my understanding of Biology concepts	357	2.94	1.03
3	I use AI-driven game-based instruction to seek help and clarification with assignments on Biology concepts	357	2.78	0.77
4	I use AI-driven game-based instruction to improve my learning outcome on Biology concepts	357	2.94	1.04
5	I use AI-driven game-based instruction for collaborative learning so as to motivate and increase engagement with Biology concepts	357	2.81	0.92
6	I use AI-driven game-based instruction to improve my overall learning experience with Biology concepts	357	2.97	0.77
	Average mean		**2.83**	

Note: Mean score < 2.00 = Low* usage *level, Mean score >2.00 ≤ 3.00=Moderate* usage *level, Mean score>3.00 = High* usage *level.

Table 2 above presents the *use of AI-driven game-based instruction*, the analysis of the reveals a **moderate usage level** among respondents. The average mean scores across the six items range from 2.53 to 2.97, all of which fall within the moderate category (mean score >2.00 ≤ 3.00). Specifically, the highest mean score (M = 2.97, SD = 0.77) indicates that students moderately agree that AI-driven game-based instruction improves their overall learning experience in Biology. Similarly, students also reported moderate usage of this instructional method to enhance understanding (M = 2.94, SD = 1.03) and improve learning outcomes (M = 2.94, SD = 1.04). The lowest mean (M = 2.53, SD = 1.06) was recorded for the direct use of AI-driven game-based instruction to learn Biology concepts, suggesting comparatively less frequent use in this specific aspect. On average, the computed mean score across all six items is **2.83**, further confirming a moderate level of engagement with AI-driven game-based instruction among the participants.

Research Question 3: What is the senior school Biology students' ease of use about AI-driven game-based instruction?

Table 3: Students ease of use of AI-driven game-based instruction

S/N	QUESTION	N	Mean	Std. Deviation
1	I find it easy to access AI-driven game-based instructions to learn Biology concepts	357	2.45	0.65
2	AI-driven game-based instruction offers a wide range of multimedia resources that help me learn Biology concepts	357	2.40	1.23
3	AI-driven game-based instruction enhances critical thinking and problem-solving skills to learn Biology concepts	357	2.69	0.96
4	AI-driven game-based instruction is creative, innovative and learner-centred	357	2.93	0.80
5	AI-driven game-based instruction can help me personalize learning of Biology concepts	357	3.17	0.87
6	AI-driven game-based instruction can improve my learning outcome on Biology concepts	357	2.91	0.90
			2.76	

Note: Mean score < 2.00 = Low* ease *level, Mean score >2.00 ≤ 3.00=Moderate* ease *level, Mean score>3.00 = High* ease *level.

Table 3 above presents the students' ease of use of AI-driven game-based instruction in learning Biology concepts, the analysis of the mean scores reveals a general trend of moderate ease of use. The average mean score across all six items is **2.76**, indicating that students moderately perceive AI-driven game-based instruction as accessible and beneficial for learning Biology. Specifically, students moderately agreed that such instruction is easy to access (M = 2.45, S.D = 0.65), provides useful multimedia resources (M = 2.40, S.D = 1.23), enhances critical thinking and problem-solving (M = 2.69, S.D = 0.96), is creative and learner-centred (M = 2.93, S.D = 0.80), and can improve learning outcomes (M = 2.91, S.D = 0.90). Notably, the highest mean score was recorded for the item stating that AI-driven instruction helps personalize learning (M = 3.17, S.D = 0.87), indicating a high level of ease in this aspect.

Discussion

The findings reveal a noticeable gap between senior school Biology students' awareness about AI in general and AI-driven game-based instruction in Ilorin South LGA, which suggests that while respondents are somewhat familiar with AI and game-based instruction individually, their understanding of AI-driven game-based instructional strategies in Biology remains moderate. This is supported by Nguyen et al., 2023, Owolarafe et al., (2024) and Zawacki-Richter, (2019). The findings reveal the moderate use of AI-driven game-based instruction for by senior school Biology students in Ilorin South LGA for various purposes such as improving learning experience and understanding Biology concepts. This is supported by the report of Aripin et al., 2024 and Gu,

2024. The findings reveal that senior Biology students in Ilorin South LGA use AI-driven game-based instructions for learning biology concepts to improve their learning outcome as well for collaborative learning to seek help with assignments. This is supported by GU, 2024 and Okunade, 2024. The findings suggests that while senior school Biology students in Ilorin South LGA find the AI-driven game-based instructions moderately easy to use, they particularly appreciate its capacity for personalized learning. This is supported by Aberbach *et al.*, 2021, Barmpakas & Xinogalos, 2023 and Huseinović, 2024.

Conclusion

The present study underscores the transformative potential of AI-driven game-based instruction in improving students' cognitive and creative engagement as well learning outcomes. These findings contribute to the growing body of evidence supporting the effective use of technology in enhancing student learning experiences, ultimately promoting personalised learning among biology students in senior secondary school. Overall, the findings provide insights into students' experiences with AI-driven game-based instruction and highlight areas for potential improvement.

Recommendation

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

1. Policy makers and other relevant stakeholders should integrate, advocate and ensure implementation of AI-driven game-based instructions into Biology curriculum.
2. The government as well as school administrators should provide support such as infrastructure for technology-enhanced learning through AI-driven game-based instruction.
3. Senior secondary school Biology students should be trained through workshops and other fora on appropriate use of AI-driven game-based instructions.

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OPPORTUNITIES AND CHALLENGES OF INTEGRATING ARTIFICIAL INTELLIGENCE IN PERSONALIZED LEARNING ENVIRONMENTS

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Abstract

The rapid evolution of Artificial Intelligence (AI) has profoundly impacted various sectors, with education experiencing one of the most transformative shifts. One of the most promising applications of AI in education is its role in facilitating personalized learning, a student-centered approach that customizes learning experiences to accommodate individual needs, preferences, abilities, and learning paces. This abstract explores the multifaceted roles of AI in personalized learning environments, highlighting the ways in which intelligent systems enhance teaching and learning processes. Through the deployment of intelligent tutoring systems, adaptive learning platforms, learning analytics, natural language processing, and personalized content recommendation engines, AI enables dynamic learning pathways tailored to each learner's profile. These technologies foster real-time feedback, targeted interventions, and self-directed learning, contributing to improved academic outcomes, increased engagement, and inclusivity, particularly for students with disabilities and those from diverse linguistic backgrounds. Furthermore, AI's predictive modeling capabilities assist educators in identifying at-risk students and making informed pedagogical decisions. Despite these benefits, challenges such as algorithmic bias, data privacy concerns, limited infrastructure in low-resource settings, and teacher preparedness persist. As educational institutions increasingly adopt AI-driven solutions, a balanced approach that emphasizes ethical considerations, stakeholder collaboration, and policy support is crucial. This paper underscores the opportunities in AI to reshape personalized learning while advocating for responsible integration strategies that ensure equity, transparency, and learner empowerment.

Keywords: Artificial Intelligence, Personalized learning, opportunities, challenges

Introduction

The integration of Artificial Intelligence (AI) in education is revolutionizing traditional pedagogical practices by introducing personalized learning approaches that adapt to the unique needs, preferences, and progress of individual learners. AI technologies are capable of tailoring educational content, pacing, and delivery methods to optimize each learner's experience. Some applications are used to facilitate humans in managing their resources as well as in the industrial world and the world of education (Wahyono, 2020). Applications in the field of research in the industrial world and the world of education continue to grow, one of which is the artificial intelligence platform used as an educational media for human needs. One of the important components in community development and human advancement is education. However, education must also change in order to remain relevant and able to prepare future generations to face technological developments and increasingly complex global challenges (Liriwati, 2023).
Artificial intelligence (AI) has emerged as a transformational force in an ever-evolving digital age that can transform the educational landscape. The use of artificial intelligence to transform curricula is essential to building relevant and adaptive education of the future. The ability of machines to learn and adapt is known as artificial intelligence. With this technology, the school curriculum can be transformed into a dynamic curriculum that is tailored to individual needs and focuses on developing skills that are relevant to the times. AI can be used to analyse large data sets and identify patterns that can inform instructional design and improve learning outcomes

(Renz &; Vladova, 2021; Rienties et al., 2020). AI technology has been a breakthrough in education as it can help students learn more easily and become more independent. This does not necessarily entail the overly dominant role of the teacher, but allows the teacher to move to an enlightening level with important keywords. This paper explores the roles of AI in personalized learning, the opportunities it presents, the challenges it poses, and its implications for stakeholders in education.

Defining Personalized Learning and Artificial Intelligence

Personalized learning refers to instructional strategies that tailor educational experiences to the learning styles, interests, goals, and pace of individual students. Personalized learning is an educational approach that tailor instruction, content and learning experiences to meet the individual needs, preferences, skills, and interests of each learner. Rather than using a "one-size-fits-all" model, personalized learning empowers students to have greater control over what, how, when, and where they learn.

Artificial Intelligence (AI), in the context of education, encompasses technologies such as machine learning, natural language processing, intelligent tutoring systems, and predictive analytics that enable adaptive learning environments. **Artificial Intelligence (AI) in Education** refers to the use of machine-based systems and algorithms to support, enhance, or automate educational processes such as teaching, learning, assessment and administration. It involves the development and application of intelligent technologies that simulate human thinking and learning processes to **personalize instruction, support educators, improve learning outcomes**, and manage educational systems more efficiently.

Opportunities of Artificial Intelligence (AI) in Personalized Learning environment

The integration of Artificial Intelligence (AI) into personalized learning has brought about a paradigm shift in the way education is delivered, moving away from traditional methods toward a more individualized approach. AI has enabled the development of sophisticated tools and platforms that cater to the unique needs of each learner, transforming the educational landscape. These are the opportunities of AI in personalized learning environment:

a. Adaptive Learning Platforms

AI-driven systems such as DreamBox or Knewton continuously analyze learner data to adjust difficulty levels, recommend resources, and identify gaps. These platforms ensure that learners receive instruction at their appropriate skill level. These systems can detect when a student is struggling with a particular concept and adjust the difficulty level or provide additional resources, such as videos, tutorials, or alternative explanations, to help the student understand the material better. This real-time adaptability not only helps in closing knowledge gaps but also in maintaining student engagement by ensuring that the learning experience remains challenging yet achievable. Adaptive learning systems are increasingly incorporating natural language processing (NLP) and machine learning techniques to better understand and respond to the nuanced needs of students. These technologies enable the systems to go beyond simple adjustments to content and pacing, allowing for more complex personalization. For example, an adaptive learning platform might analyze a student’s previous interactions with educational materials to predict which types of content text, video, or interactive simulations are most effective for that particular learner. This level of personalization ensures that each student receives a learning experience that is truly tailored to their unique needs, preferences, and learning.

b. Intelligent Tutoring Systems (ITS)

Artificial Intelligence powers ITS platforms that simulate one-on-one human tutoring. These systems assess student responses in real time and adjust instruction accordingly. For instance, platforms like Carnegie Learning and MATHia provide immediate feedback and hints customized to student needs. The system's ability to adapt in real-time ensures that each student receives the appropriate level of challenge and support, which is essential for effective learning. Beyond simple problem-solving, ITS are increasingly capable of engaging in more complex interactions with students.

Advances in Artificial Intelligence, particularly in NLP, have enabled these systems to understand and respond to student queries in a more natural and conversational manner. This development allows ITS to provide explanations, ask probing questions and even engage in Socratic dialogue, fostering deeper understanding and critical thinking. The goal of these systems is not just to help students arrive at the correct answer but to develop their problem-solving skills and conceptual understanding.

c. Learning Analytics and Predictive Modelling

Artificial Intelligence analyzes student performance data to predict future outcomes and inform interventions. Educators can identify at-risk students early and provide targeted support, thereby improving retention and achievement rates. AI-driven learning analytics tools, such as those developed by Civitas Learning, leverage machine learning algorithms to analyze student data and provide actionable insights. These insights can inform instructional decisions, such as identifying students who are at risk of falling behind, recommending targeted interventions, or adjusting curricula to better meet the needs of the student population. Predictive analytics, a subset of learning analytics, takes this a step further by using AI to predict future student outcomes based on current and historical data. For example, predictive models can identify students who are at risk of failing a course or dropping out, allowing educators to intervene early and provide the necessary support to keep students on track. In addition to supporting educators, learning analytics can also empower students to take greater control of their learning. By providing students with personalized feedback and insights into their performance, these tools can help learners identify their strengths and weaknesses, set goals, and monitor their progress. This self- regulated learning approach is particularly valuable in online and blended learning environments, where students may have more autonomy over their learning paths

d. Natural Language Processing (NLP) and Chatbots

Artificial Intelligence chatbots and virtual assistants (e.g., Duolingo Bots, Google's Socratic app) can answer student queries, offer explanations, and support language acquisition using NLP technologies. These tools enable continuous learning outside the classroom.

e. Personalized Content Recommendation

Artificial Intelligence systems like Coursera and Edmodo recommend personalized learning paths based on learners' goals, prior performance, and engagement patterns, enhancing motivation and content relevance.

f. Assistive Technology for Inclusive Learning

Artificial Intelligence supports learners with disabilities through voice recognition, text-to-speech, emotion detection, and content simplification tools, ensuring inclusivity in personalized learning environments.

Benefits of AI-Driven Personalized Learning

- **Improved Learning Outcomes**: Students progress at their own pace and receive feedback aligned with their cognitive level.
- **Equity and Inclusion**: AI tools can provide support to underserved and differently-abled learners.
- **Increased Engagement**: Personalized pathways keep learners motivated and invested in their learning journey.
- **Scalability**: AI enables scalable personalization even in large or remote classrooms.

Challenges and Considerations

a. Data Privacy and Security: Personalized systems require vast amounts of learners' data, raising concerns about data protection. This data is essential for creating personalized learning experiences, but it also raises significant concerns about privacy and the potential for misuse. The sensitive nature of student data necessitates robust data protection measures to prevent unauthorized access, data breaches, and other forms of cyber threats. Educational institutions must adhere to strict data governance policies that comply with legal frameworks.

b. Bias in AI Algorithms: The issue of bias in AI algorithms is another critical ethical consideration. AI systems are only as unbiased as the data they are trained on. If the training data contains biases, whether related to race, gender, socio-economic status, or other factors, these biases can be perpetuated and even amplified by the AI system, leading to unfair or discriminatory outcomes. If an AI system is trained on data that predominantly represents a certain demographic group, it may perform less accurately or effectively for students from other groups. This can result in biased assessments, recommendations, and learning experiences, which may disadvantage certain students. To mitigate this risk, it is crucial to ensure that AI systems are trained on diverse and representative data sets that reflect the full range of student experiences and backgrounds. The algorithms themselves must be designed with fairness and inclusivity in mind.

c. Teacher Role and Training: The integration of AI in education also raises important questions about the evolving role of teachers. While AI can provide personalized instruction and support, it cannot replace the human element of teaching, which is critical for fostering relationships, providing emotional support and facilitating complex discussions. As AI becomes more prevalent in the classroom, the role of teachers is likely to shift from being the primary source of knowledge to becoming facilitators and mentors who guide students through personalized learning experiences. This shift requires teachers to develop new skills, particularly in the use of AI tools and the interpretation of data-driven insights. Professional development and training programs are essential to equip educators with the knowledge and skills they need to effectively integrate AI into their teaching practices. There is a need to strike a balance between the use of AI and the preservation of the human elements of education. While AI can offer personalized learning paths and immediate feedback, the role of teachers in providing context, encouraging critical thinking, and fostering a sense of community within the classroom remains irreplaceable. Educators must be empowered to use AI as a tool that enhances their teaching rather than as a substitute for their expertise and intuition.

d. Digital Divide: Not all learners have access to the devices and internet connectivity required for AI-powered learning. The digital divide is particularly problematic, as it hinders equitable access to the benefits of technology-driven, tailored educational experiences. It includes disparities in **Access Divide (**availability of digital devices and internet services, differences in infrastructure between urban and rural or poor communities), **Usage Divide** (even where access exists, students may not know how to use digital tools effectively, variation in digital literacy among students and teachers) and **Quality Divide (**some learners receive rich, adaptive, AI-powered learning experiences**,** others access only basic content with little personalization or interactivity). Equity and access are essential to prevent the exacerbation of existing educational disparities, as the benefits of AI should be available to all students, regardless of their background or geographic location.

Policy Implications and Recommendations

- **Invest in Infrastructure**: Ensure equitable access to technology and internet connectivity.
- **Teacher Training**: Educators must be trained to interpret AI insights and integrate them into instruction.
- **Ethical AI Use**: Develop and enforce policies around responsible AI usage in education.
- **Ongoing Research**: Support empirical studies to evaluate the effectiveness and long-term impact of AI in personalized learning.

Conclusion

Artificial Intelligence plays transformative roles in enabling personalized learning by adapting instruction, supporting inclusive practices, and providing real-time insights into learner progress. The current developments in AI-powered personalized learning, including adaptive learning systems, intelligent tutoring systems and learning analytics, have already begun to demonstrate the profound impact that AI can have on education. These technologies are not only making learning more personalized but also more dynamic, interactive and responsive to the needs of individual students. However, the full realization of AI's potential in education is contingent upon addressing several critical challenges and ethical considerations. Issues of data privacy and security are paramount, as the sensitive nature of student data requires stringent protections against unauthorized access and misuse. Similarly, ensuring equity and access is essential to prevent the exacerbation of existing educational disparities, as the benefits of AI should be available to all students, regardless of their background or geographic location. Bias in AI algorithms presents another significant challenge, as the risk of perpetuating and amplifying societal biases through AI-driven educational tools is a real and pressing concern. It is crucial that these systems are developed with fairness and inclusivity at their core, using diverse and representative data sets and undergoing continuous monitoring and evaluation to detect and mitigate any biases that may arise. While its promise is vast, stakeholders must address ethical, infrastructural, and pedagogical challenges to harness AI effectively. Artificial Intelligence, when implemented responsibly, has the potential to democratize access to quality education and empower learners across diverse contexts.

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SUSTAINABLE EDUCATION IN THE DIGITAL AGE: LEVERAGING TECHNOLOGICAL ADVANCEMENTS

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Abstract

Sustainable education has emerged as an important model, aiming to equip learners with the knowledge and skills necessary for enhancing sustainable development. This review explores the impact of digital technologies on the sustainability of educational practices, looking into how digital tools and platforms can be harnessed to promote environmental stewardship, social equity, and economic viability. The paper examined recent literature on the integration of educational technology in various learning environments, highlighting innovative practices such as digital learning platforms, online collaborative tools, and adaptive learning systems. It also addresses the challenges and opportunities associated with the adoption of digital technologies in educational settings, with a focus on bridging the digital divide, ensuring inclusivity and accessibility in the educational process. Through an analysis of case studies and empirical data, this review underscores the transformative potential of technology in creating resilient educational frameworks that not only enhance learning outcomes but also contribute to the global sustainability. The findings underscore the necessity for policymakers, educators, and technologists to collaborate in designing and implementing strategic initiatives that leverage technological advancements for sustainable education in the digital age.
Keywords: Technological advancements, Sustainable education, Digital learning platforms, educational technology integration

Introduction

In education, the integration of technology has become an essential part of enhancing teaching and learning practices. The evolution of technology has revolutionized the traditional methods of teaching and learning, presenting both opportunities and challenges for educators. As educators maneuver this digital transformation, understanding their perspectives on technology integration is important for enhancing sustainable educational practices. Sustainable education has gained prominence as an essential model for equipping learners with the knowledge and skills necessary to promote sustainable development. This model of education seeks to address the interconnected challenges of environmental stewardship, social equity, and economic viability, all of which are key for achieving global sustainability goals (UNESCO, 2017).

Sustainable education transcends academic achievement, as it encompasses a holistic approach that nurtures intellectual curiosity, and empowers individuals to become agents of positive change (Hogan & O'Flaherty, 2022). Oluwagbemileke, (2024), stated that sustainable education in the digital age should prioritize the development of critical thinking, creativity, and problem-solving skills among learners. By harnessing the power of technology, educators can create immersive learning environments that stimulate curiosity and encourage exploration. Integration of educational technology in various learning environments significantly transformed how education is delivered and experienced. This transformation is driven by the need to provide learners with the knowledge and skills necessary for promoting sustainable development. Sustainable education aims to promote social equity, economic viability, and technological advancements, which are pivotal in achieving these goals (Chankseliani & McCowan, 2020). One of the primary ways educational technologies has been integrated into learning environments is through digital learning platforms. These platforms offer loads of resources and tools that facilitate both teaching and learning (Aljawarneh, 2020). For instance, e-learning platforms provide access to educational contents from anywhere in the world, breaking geographical barriers and ensuring that education is more accessible (Adeniyi, et al., 2024). These platforms often include interactive elements such as quizzes, forums, and multimedia resources, which enhance engagement and retention of educational information.

These platforms not only prepare learners for the challenges of the future but also cultivates a mindset of lifelong learning. Also, the advent of digital platforms and virtual learning environments has revolutionized the delivery of educational content, enabling real-time collaboration, personalized learning, and the seamless exchange of knowledge across the world (Alam & Mohanty, 2023). Online collaborative tools and adaptive learning systems have emerged as technological innovations that can enhance sustainable education (Cebrián, Palau, & Mogas, 2020). These digital tools and platforms offer unique opportunities for collaborative learning and personalizing learning experiences. Online collaborative tools facilitate real-time communication, file sharing, and collaborative document editing, enabling learners to work together perfectly regardless of their physical locations. Platforms like Google Workspace and Microsoft Office 365 have changed the way learners and educators collaborate on projects, assignments, and research. Using these tools can make group-based in-class activities, projects and assignments highly engaging for a diverse student body while also developing skills valued in the workplace (Lake, 2022). Online collaborative tools not only promote collaborative learning but also reduce the need for physical resources, contributing to environmental sustainability. Through collaboration and knowledge sharing, these tools can facilitate the development of critical thinking, problem-solving, and decision-making skills, which are important in addressing sustainability challenges (Straková & a Cimermanová, 2018). However, adaptive learning systems on the other hand, leverage artificial intelligence and machine learning algorithms to personalize learning experiences based on individual learners' needs, preferences, and abilities. These systems analyze learners' performance data, identify knowledge gaps, and dynamically adjust the content, pace, and delivery methods to optimize learning outcomes (Almohammadi, Hagras, Alghazzawi, & Aldabbagh, 2017).

Artificial intelligence (AI), blockchain, and digital learning platforms, have the potential to revolutionize education by making it more accessible, inclusive, and effective. While the integration of technologies like artificial intelligence (AI) holds promise for tailoring educational experiences to individual learning styles and aptitudes (Onesi-Ozigagun et al, 2024), digital learning systems can also analyze student performance data, identify knowledge gaps, and adjust instructional strategies, ensuring balanced learning. The path toward sustainable education in the digital age encompasses not only the integration of technology into learning environments but also the adoption of practices that ensure the longevity and inclusive educational systems. Furthermore, sustainable education in the digital age necessitates a shift in pedagogical approaches, emphasizing critical thinking, problem-solving, and digital literacy skills. Educators and administrators must embrace innovative teaching methodologies that leverage digital tools while instilling values of social responsibility in learners (Shava, 2022).

Hence, the implementation of policies in facilitating digital literacy and access to technology in schools, is important for sustainable education (Falloon, 2020). Likewise, (Spiteri & Chang-Rundgren, 2020), highlighted the importance of teacher training programs in the effective use of educational technology, while (Azubuike, Adegboye, & Quadri, 2012), argue for the need to address the digital divide, ensuring that learners from all backgrounds have equal access to digital resources. Given this, the digital age presents both challenges and opportunities for sustainable education. On one hand, rapid technological advancements have enabled greater access to information, innovative learning tools, and collaborative platforms. However, these developments have also raised concerns about digital divides, environmental impact, and the need for digital literacy (Blazic & Blazic, 2020).

Statement of the Problem

A significant challenge for sustainable education is the digital divide, which remains a barrier to equitable access to educational technology. The digital divide refers to the gap between individuals who have access to modern information and communication technologies and those who do not. This gap is often influenced by socio-economic status, geographic location, and the availability of infrastructure (Calderón, 2018). For instance, while platforms like Google Classroom and Microsoft Teams offer substantial benefits for learning remotely and collaboration, their effectiveness is severely limited for learners in low-income or rural areas who lack reliable internet access and digital devices (Faturoti, 2022). This disparity not only sets backs the inclusivity and accessibility of education but also exacerbates existing educational inequalities, undermining the goal of sustainable education. Further, the implementation of adaptive learning systems, which use artificial intelligence to personalize learning experiences, introduces new challenges, as these systems require extensive data collection and analysis to tailor educational content to individual student needs. Without data security protocols, the risk of data breaches and misuse of sensitive information could erode trust in these technologies and limit their adoption in educational institutions (Anub, et al., 2024). Additionally, the cost of implementing and maintaining advanced educational technologies can be high for many educational institutions. Adaptive learning systems and online collaborative tools often require substantial initial investments in hardware, software, and training (Grimus, 2020). For underfunded schools, particularly those in developing regions, these costs can be insurmountable, preventing them from benefiting from technological advancements. This financial barrier further entrenches educational disparities and limits the global reach of sustainable educational practices.

The educational sector in Africa, particularly in Nigeria, faces significant challenges in achieving sustainable and equitable access to quality education. Despite the rapid advancements in technology, many countries in Africa, including Nigeria, struggle to effectively integrate digital tools and resources into their educational systems (Martens, et al., 2020), hence, face a unique set of obstacles in achieving sustainable digital education. With a significant youth population and a demand for quality education, the country needs to leverage technological innovations to enhance access and quality (Olanrewaju & Afolabi, 2022). However, the digital divide, characterized by disparities in access to technology, infrastructure, and digital literacy, poses a significant barrier to equitable educational opportunities.

The problem statement for this study centers around the need to develop a comprehensive framework that will address the multifaceted challenges of sustainable digital education in Nigeria. This framework would encompass strategies for bridging the digital divide, strengthen digital literacy among educators and learners, and integrating technology into the curriculum in a manner that enhances learning outcomes while preserving cultural and contextual relevance.

Literature Review

Impact of Digital Technologies on the Sustainability of Educational Practices

The impact of digital technologies on the sustainability of educational practices is multifaceted, encompassing areas of accessibility, efficiency, and environmental footprint.

Accessibility is a component of sustainable education, ensuring that all learners, regardless of their socio-economic status or geographic location, have access to quality education, as it has the potential to change education by breaking down traditional barriers to learning (Takyi, Amponsah, Asibey, & Ayambire, 2019). For example, online learning platforms such as Coursera and edX offer free or low-cost courses from institutions, making quality education accessible to a global learner (Suresh & Srinivasan, 2020). These platforms allow learners from remote and underserved areas to access educational resources that would otherwise be unavailable to them. Further, access to blended learning could be the solution for providing education in the context of the 21st century, as the extensive integration of open educational resources, massive open online courses, social media and meeting has opened up the minds of those seeking knowledge, further enabling them to receive the necessary educational inputs, training and skills (Bordoloi, Das, & Das, 2021). Also, digital resources can be designed with accessibility features, such as closed captions, transcripts, and adjustable font sizes, ensuring that educational materials are inclusive and cater to diverse learning needs (Navarrete & Luján-Mora, 2018).

However, it is essential to recognize that the digital divide is a factor in the unequal access to digital technologies and the internet, which remains a significant challenge (Fang, et al., 2019). This divide can increase existing inequalities and perpetuate educational disparities, undermining the sustainability of educational practices. Digital divide represents the gap between individuals who have access to modern information and communication technology (ICT) and those who do not. In Nigeria, this divide is a significant barrier to sustainable education, as it limits access to digital resources and online learning opportunities (Ogbo, Brown, Gant, & Sicker, 2021). The COVID-19 pandemic further exacerbated this divide, which forced a shift to online education. The pandemic revealed the stark disparities in digital access and called for a paradigm shift in higher education (Ajonbadi, Olawoyin, & Adekoya, 2023). The digital divide is a multifaceted phenomenon that encompasses various dimensions, including socioeconomic status, geographic location, age and gender (Vartanova & Gladkova, 2019). The digital divide is not just about physical access to technology but also encompasses the skills and motivation required to effectively utilize these technologies. This was further reinforced by (Scheerder, van Deursen, & van Dijk, 2019), who highlight the importance of digital literacy and the ability to critically evaluate and create digital content. A key factor contributing to the digital divide is the uneven distribution of internet infrastructure and broadband connectivity, particularly in rural and remote areas. This disparity not only limits access to educational and economic opportunities but also heightens existing social inequalities Consequently, bridging this gap has become a priority for policymakers and stakeholders worldwide (Jamil, 2021).

However, the digital divide is not limited to access to ICT devices or the internet but also includes unevenness in the ability to effectively use the technologies, including divides in terms of access or no access to information, ICT devices, or the internet. A review of the digital divide by (Lythreatis, Singh, & El-Kassar, 2022), identified factors affecting the digital divide, including sociodemographic, socioeconomic, personal elements, and social support. It further highlighted the need for future research to address these factors to bridge the digital divide. Also, it emphasized the need for research to extend established models of digital inequalities, critically examine the effects of digital divide interventions, and better link digital divide research with research on sustainability.

Digital technologies improve efficiency through the reduction of physical resources. The adoption of e-learning platforms, digital textbooks, and online course materials has led to a substantial decrease in paper consumption and printing costs (Kapuka, Shumba, & Munthali, 2017). Also, efficiency in educational settings can be achieved by reducing the reliance on physical materials. Traditional education methods often involve significant use of ink, and physical textbooks. The shift to digital platforms, such as e-books and online course materials, has considerably decreased the need for these physical resources (Molaudzi, 2020). Moreover, digital submission and grading systems further enhance resource efficiency. These tools such as Google Classroom allow learners to submit assignments electronically, which teachers can then grade and provide feedback on digitally. This process streamlines administrative tasks, allowing educators to allocate more time to instructional activities.

Integration of educational technology in various learning environments.

The integration of educational technology into various learning environments is important for sustainable education in the evolving digital age. As technology continues to advance, educators and institutions must adapt to leverage these advancements effectively to aid teaching and learning outcomes. This study explores how digital advancements are leveraged in traditional classrooms, online learning, blended learning, STEM learning Environments.

Traditional Classroom Environment

Traditional classroom environment typically it refers to a physical place where a teacher delivers instruction to a group of learners, primarily through lectures, discussions, and assignments. Learners can gain interactivity, motivation, accessibility and organization. This enables direct communication between teacher and learners and as a result, learners are able to grow their work activity and directly clearing doubts of a particular subject in timely manner. While this model has been effective, the advancements in technology have necessitated its evolution. While the setting remains a cornerstone of learning, the integration of educational technology has emerged as an important factor in enhancing teaching and learning processes (Nicolaou, Matsiola, & Kalliris, 2019). Moreover, the integration of technology in traditional classrooms is primarily driven by the need to enhance learning outcomes and prepare learners for a technology-driven world. As (Webb & Doman, 2019) suggested, when technology is aligned with educational goals, it can significantly improve student learning outcomes. Hence, digital educational tools allow for a more personalized learning experience, catering to diverse learning styles and paces, which traditional methods may not fully address. With educational technology learners experience is more interactive and engaging. Tools such as multimedia presentations, simulations, and online resources provide learners with varied ways to access and process information (Faiz, 2021). For instance, the use of smartboards allows teachers to present dynamic content and facilitates interactive lessons, which can improve student engagement and understanding. Additionally, digital tools such as learning management systems (LMS) like Moodle enable teachers to manage course materials, track student progress, and communicate with learners more efficiently (Deliwe, 2020).

Online learning

Online learning environments have transformed education, offering a range of benefits that cater to diverse learning needs and preferences. These environments, often facilitated through Virtual Learning Environments (VLEs) or Learning Management Systems (LMS), providing learners and educators with flexible, accessible, and interactive platforms for teaching and learning (Maliki, Kusuma, Tabrani, & Hamidah, 2021). These Learning environments could promote inclusivity by allowing learners who may feel anxious in traditional classroom settings to participate more freely. This is particularly beneficial learners who might struggle with in-person interactions. Additionally, VLEs are accessible to anyone with a stable internet connection and a computer, enabling learners with mobility challenges to engage in education without physical barriers (Nwabude, Ogwueleka, & Irhebhude, 2020). Online learning environments offers flexibility, where learners can learn at their own pace, accessing course materials and lectures at times that suit them best. This self-directed approach allows for better time management and accommodates individual learning styles (Rosar & Weidlich, 2022). The study further stated that creative learners reported more motivation after learning in an unstructured online learning environment, whereas non-creative learners reported relatively better learning experiences in the highly structured condition. Also, virtual online learning enables learners connect with others from different backgrounds, giving a sense of collaboration. This interaction not only enhances teamwork skills but also broadens learners' perspectives by exposing them to different ideas (Herrera-Pavo, 2021). Hence, integrating educational technologies into the online classroom can enhance a student-centered environment that supports learners' needs. (Samoylenko, Zharko, & Glotova, 2022) emphasizes the importance of designing flexible and reliable online learning environments that require both technical skills (digital literacy fundamentals) and methodological assistance. Therefore, learners and teachers must have access to appropriate devices and a reliable internet connection to effectively participate in online learning.

Blended learning

Blended learning, as defined by (Garrison & Norman, 2007), is a pedagogical approach that combines face-to-face and online learning to improve the overall learning experience. It involves a purposeful selection of activities and resources to address student needs, interests, and learning styles. It as a model that merges traditional classroom instruction with online learning activities, allowing for a more personalized and adaptable educational experience. This integration is particularly relevant in the context of sustainable education, as it enables the incorporation of sustainability principles into the curriculum (Dakhi, Jama, Irfan, Ambiyar, & Ishak., 2020). The study concluded that, the strength of the blended learning model is that it can increase interaction between learners anytime and anywhere, as rapidly growing technology integration has brought powerful changes to the educational system and improved digital skills for learners and lecturers. The integration of educational technology into blended learning is grounded in constructivist learning theories (Vygotsky, 1978), which emphasize the active construction of knowledge through interaction with the environment. Also, (Kumar, et al., 2021), stated that blended learning combines face-to-face instruction with online learning, enabling personalized and learner-centered experiences. In the integration of educational technology in blended learning, different technological tools have been employed. Learning management systems (LMS) (Al-Hunaiyyan, Al-Sharhan, & AlHajri, 2020) have become ubiquitous, providing platforms for content delivery, assessment, and communication. Furthermore, the proliferation of mobile devices has enabled ubiquitous learning, offering opportunities for anytime, anywhere access to educational resources (Criollo-C, Guerrero-Arias, Jaramillo-Alcázar, & Luján-Mora, 2021).

STEM learning

STEM (Science, Technology, Engineering, and Mathematics) learning environments are spaces where learners engage in active, contextualized, and meaningful learning experiences through participation, collaborative work, problem-solving, integration of disciplines, creativity, and autonomy. These learning environments aim to develop 21st-century competencies and skills for life. The STEM learning environments involve the integration of two or more STEM disciplines to solve problems and importantly, learners using their knowledge and skills from various fields to tackle real-world challenges (Dare, Keratithamkul, Hiwatig, & Li, 2021); the study showed that all teacher who participated in the study viewed STEM education from an integrative perspective that promotes the development of 21st century skills, using real-world problems to motivate learners. The findings also revealed that teachers have varying ideas related to the STEM disciplines within integrated STEM instruction, which could assist teacher in preparing high-quality professional development experiences. Also, at the core of STEM education is inquiry-based learning, where learners actively construct knowledge through exploration and experimentation. This approach encourages learners to ask questions, formulate hypotheses, and seek answers through investigation. In the study of (Amin, Rahmawati, Sudrajat, & Mardiah, 2022), on enhancing primary school learners' critical thinking by implementing an interdisciplinary STEM approach, it was observed that learners were experiencing the enhancement of critical thinking skills through information exploration and project discussion to engage them in identifying questions at issues raised in learning. Also, facilitating learners to integrate their thought into real-life and project-making leads them to improve their conceptual understanding. Furthermore, educational technology offers a lot of tools and resources that can transform STEM learning. Simulations, virtual laboratories, and interactive software provide learners with hands-on experiences that complement traditional classroom instruction (Hernández- de-Menéndez, Guevara, & Morales-Menendez, 2019). Moreover, these technologies can facilitate problem-solving, and critical thinking, which are key competencies for STEM success (Mishra & Koehler, 2006). For implementation, researchers like (Dikmen & Demirer, 2022) emphasize the importance of Technological Pedagogical Content Knowledge (TPACK) for effective technology integration. This means that teachers need to possess a deep understanding of both technology and pedagogy to leverage technology effectively in their classrooms.

While the potential benefits of technology integration in education are substantial, there are also challenges to overcome. These include issues such as teacher training, lack of adequate infrastructure, and concerns about student screen time. To address these challenges, policymakers, educators, and technology developers need to collaborate to create supportive learning environments. However, despite these challenges, the opportunities for technology-enhanced education are unlimited, as emerging technologies such as augmented reality, virtual reality, and artificial intelligence offer new possibilities for engaging and immersive learning experiences.

Challenges and opportunities associated with the adoption of digital technologies in education

The adoption of digital technologies in education is the integration of digital tools and platforms into teaching and learning processes (Valverde-Berrocoso, Ferna´ndez-Sa´nchez, Dominguez, & Sosa-Dı´az, 2021). This shift has been driven by the necessity to enhance learning outcomes, improve accessibility, and prepare learners for a digital future. This process involves a shift from traditional methods to more technologically-driven approaches to enhance student learning outcomes and achievement, teaching methodologies, and overall educational efficiency. This process encompasses acquisition, implementation, and sustained use of digital technologies within educational institutions. The initial phase of adoption involves procuring necessary hardware, software, and digital resources (Alenezi, 2023). This includes devices such as computers, tablets, and interactive whiteboards, as well as educational software, learning management systems (LMS), and online content platforms. Further, is the implementation of the technology, which focuses on integrating digital technologies into the curriculum, pedagogical issues, and assessment practices. This will involve teacher training, curriculum development, and the creation of digital learning materials. On sustainability, the long-term adoption of digital technologies will require ongoing support, maintenance, and professional development. It involves ensuring that technology is used effectively in teaching, learning and consistently over time, and adapting to emerging technological advancements (Gros & García-Peñalvo, 2023).

Factors Influencing Adoption

Several factors influence the adoption of digital technologies in education:

- Teacher readiness: Teachers' technological literacy, pedagogical knowledge, and willingness to embrace change are important for successful technology adoption. (Raygan & Moradkhani, 2020), (Akar, 2019), (Mardiana, 2020).
- Infrastructure: Adequate internet connectivity, computer labs, and technical support are essential for effective technology integration. (Agormedah, Henaku, Ayite, & Ansah, 2020), (Dong, Xu, Chai, & Zhai, 2019).
- Curriculum alignment: The curriculum should be aligned with the use of digital technologies to maximize their impact on student learning. (Qureshi, Khan, Raza, Imran, & Ismail, 2021), (Liu, Geertshuis, & Grainger, 2020)
- Leadership support: Strong leadership and administrative support are vital for creating a conducive environment for technology adoption. (Clohessy, Acton, & Rogers, 2018), (Karakose, Polat, & Papadakis, 2021).
- Digital divide: Access to technology and digital literacy vary among learners, which can impact the effectiveness of technology integration. (Youssef, Dahmani, & Ragni, 2022), (van de Werfhorst, Kessenich, & Geven, 2022).

Challenges

1. Infrastructure and Access: One primary challenge is the lack of adequate infrastructure, particularly in developing countries like Nigeria. Many educational institutions struggle with limited access to reliable internet and digital devices, which hinders effective technology integration (Ndibalema, 2022).
2. Teacher Training and Support: Effective adoption requires that teachers are adequately trained to use digital tools. Studies indicate that many educators feel unprepared to integrate technology into their teaching practices, leading to inconsistent application and underutilization of available resources (Opeyemi, et al., 2019), (Bui, 2022).

3. Resistance to Change: Some educators and institutions resist adopting new technologies due to fear of change or a lack of understanding of the benefits. This resistance can slow down the integration process and limit the potential advantages of digital tools (Konaklı & Akdeniz, 2022), (Masry-Herzalah & Dor-Haim, 2022).

Discussion

The impact of digital technologies on educational sustainability is complex and multifaceted. While they offer significant benefits in terms of accessibility and efficiency, they also present challenges that must be addressed to ensure truly sustainable educational practices. The potential for digital technologies to democratize education and break down barriers to learning is immense. Online platforms and resources can reach learners in remote or underserved areas, providing access to high-quality educational content that was previously unavailable. This increased accessibility aligns well with sustainability goals, as it promotes equitable access to education. However, the digital divide remains a significant obstacle to realizing this potential fully. The uneven distribution of digital access and skills can exacerbate existing inequalities, undermining the sustainability of educational practices. Addressing this divide requires a multifaceted approach, including improving infrastructure, enhancing digital literacy, and ensuring equitable access to devices and the internet. From an efficiency standpoint, digital technologies offer clear benefits. The reduction in physical resource consumption, such as paper and textbooks, aligns with sustainability goals by decreasing waste and conserving resources. Additionally, the streamlining of administrative tasks through digital tools can potentially lead to more effective use of educators' time and resources. The environmental impact of digital technologies in education is more nuanced. While they reduce the need for physical resources, the energy consumption of data centers and the problem of electronic waste present new sustainability challenges. To fully realize the sustainability potential of digital technologies in education, these issues must be addressed through strategies such as improving energy efficiency, transitioning to renewable energy sources, and implementing effective e-waste management practices.

Further, integration of educational technology across various learning environments represents a significant shift in educational practices, aiming to enhance learning outcomes and prepare students for a technology-driven world. This integration aligns with the principles of sustainable education by promoting accessibility, efficiency, and adaptability in learning. In traditional classroom settings, technology integration has transformed the learning experience from a teacher-centered to a more student-centered approach. The use of digital tools and LMS not only enhances engagement but also allows for more personalized learning experiences. This shift addresses diverse learning styles and paces, potentially leading to improved learning outcomes. Online learning environments have revolutionized access to education, breaking down geographical and physical barriers. The flexibility and accessibility offered by VLEs promote inclusivity, allowing learners with various needs and circumstances to participate in education. However, the success of online learning heavily depends on digital literacy and access to technology, highlighting the ongoing challenge of the digital divide. Blended learning emerges as a balanced approach, combining the benefits of face-to-face instruction with online learning. This model allows for the integration of sustainability principles into the curriculum while providing a flexible and personalized learning experience. The success of blended learning relies on the effective use of technology and the adaptation of pedagogical approaches to leverage both online and in-person components. In STEM learning environments, technology integration plays a important role in developing 21st-century skills. The use of simulations, virtual laboratories, and interactive software provides hands-on experiences that might be otherwise difficult or expensive to implement. This approach not only enhances understanding of complex concepts but also promotes problem-solving and critical thinking skills essential for STEM fields. While the benefits of technology integration in education are significant, challenges remain. These include the need for adequate teacher training, infrastructure development, and addressing concerns about excessive screen time. The concept of Technological Pedagogical Content Knowledge (TPACK) emphasizes the importance of teachers understanding both technology and pedagogy to effectively implement these tools.

One of the primary challenges highlighted is the issue of infrastructure and access. This is particularly pronounced in developing countries, where reliable internet connectivity and access to digital devices may be limited. This challenge underscores the global digital divide and raises concerns about educational equity. As education becomes increasingly reliant on digital technologies, there's a risk of widening the gap between those with access to these resources and those without, potentially exacerbating existing educational disparities.

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ENHANCING DIGITAL LITERACY AMONG JUNIOR SECONDARY SCHOOL STUDENTS IN ILORIN: A TRAINING INTERVENTION STUDY

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Abstract

Digital literacy is increasingly recognized as a critical skill for effective participation in today's knowledge-based society, particularly among youth in developing countries. This study assessed the implementation of a digital literacy program designed to enhance junior secondary school students' digital competencies. The program was developed based on the *National Digital Literacy Framework* of the Federal Ministry of Communications, Innovation and Digital Economy (FMCIDE), ensuring alignment with national digital education goals. Guided by a one-group posttest only design, the study evaluated the effectiveness of the program using expert validation, student reaction data, and post-intervention performance scores. During the development phase, instructional materials and assessment instruments were reviewed by experts to establish content validity and usability. Following refinement, the program was delivered to junior secondary school students, and data were collected through a structured reaction questionnaire and a digital skills performance test. Expert ratings confirmed the content relevance and pedagogical quality of the program. Students' reactions revealed strong enjoyment and perceived relevance (M = 3.00), though areas like participation and tool navigation received lower mean scores. Performance results demonstrated satisfactory acquisition of digital skills across competencies such as file management, internet use, and word processing. The study concludes that the program is instructionally sound and suitable for enhancing foundational digital skills. It recommends broader implementation with improved engagement strategies and suggests future research with control and pretest-posttest designs.

Keywords: Digital Literacy, Digital Literacy Training, Digital Divide, Training Programme

Introduction

In the contemporary world, digital literacy has become an essential skill for full participation in various aspects of life, ranging from education and employment to communication and accessing services. Digital literacy refers to the ability to use digital technologies, such as computers, smartphones, and the internet, to find, evaluate, create, and communicate information effectively. As societies around the world continue to embrace the digital age, digital literacy has emerged as a crucial determinant of an individual's success. It enables individuals to engage with the world, stay informed, participate in the economy, and improve their quality of life. However, despite the ubiquity of digital technologies, a significant gap exists between those who have access to and the necessary skills to use technology and those who do not. This gap, known as the "digital divide," is particularly evident in low-income communities, where access to technology is limited and the necessary digital skills are often lacking (Ojo, 2022). In many low-income communities across Nigeria, digital literacy remains a critical challenge. Limited access to digital devices, high-speed internet, and inadequate infrastructure prevent individuals from fully participating in the digital world. For instance, a significant number of Nigerians in rural areas do not have regular access to the internet, and many households cannot afford devices such as personal computers or smartphones. The lack of reliable electricity further complicates matters, as many communities face power outages that affect the use of digital devices. These barriers significantly limit opportunities for educational advancement, career growth, and social inclusion (Ogunleye & Alabi, 2023). A report by the National Bureau of Statistics (NBS) reveals that internet penetration in rural Nigeria is significantly lower than in urban centers, further exacerbating the digital divide (NBS, 2023).

The lack of digital skills is another contributing factor to the digital divide. Many individuals in low-income communities in Nigeria are unable to navigate the internet, use software applications, or access online resources due to a lack of formal education and exposure to technology. A study by Akinsola (2022) found that approximately 50% of Nigerian students, particularly those from disadvantaged backgrounds, lack the basic digital skills needed to succeed in a technology-driven world. Furthermore, adult learners in these communities often face significant barriers to digital literacy training due to factors such as illiteracy, limited access to training facilities, and financial constraints. As a result, many individuals are excluded from digital opportunities that could improve their socio-economic status and overall quality of life (Uzoechi & Nwosu, 2023).

Digital literacy is particularly important for young people in low-income communities, as it can open doors to better educational opportunities and future employment. With the increasing integration of technology in education, students who lack digital skills are at a significant disadvantage. Online learning, which became even more prevalent during the COVID-19 pandemic, requires access to the internet and digital devices. In Nigeria, many students in lowincome communities were unable to participate in online classes, which led to a widening educational gap between them and their more affluent peers (Ibrahim & Mohammed, 2023). Furthermore, digital literacy is becoming a key requirement for employment in many sectors, as more jobs demand basic digital skills. In a country like Nigeria, where youth unemployment rates are high, the lack of digital skills limits job prospects and economic mobility for young people in low-income areas (Aliyu & Adebayo, 2024).

The barriers to digital literacy in low-income communities in Nigeria are further compounded by the absence of sufficient digital infrastructure. In many rural areas, internet connectivity is either slow or non-existent, making it difficult for residents to access online resources, communicate effectively, or participate in digital economies. According to the Nigerian Communications Commission (NCC, 2023), rural internet penetration remains below 30%, which is significantly lower than in urban areas. This digital gap has serious implications for access to education, healthcare, and government services, which are increasingly moving online. Rural dwellers in Nigeria often miss out on these vital services, which deepens their marginalization and hinders their ability to improve their living standards (Bello, 2022).

Digital literacy programs have emerged as a potential solution to these challenges. These programs aim to equip individuals with the skills needed to navigate the digital world and unlock opportunities for personal, educational, and professional growth. Several initiatives, both government and non-governmental, have been launched across Nigeria to improve digital literacy among disadvantaged groups. For example, the Nigerian government has introduced the National Digital Literacy Program (NDLP), which aims to train millions of Nigerians in digital skills over the next few years (Nigerian Communications Commission, 2023). Similarly, various NGOs, such as the Digital Bridge Institute and the Nigerian Internet Governance Forum, have been involved in providing digital literacy training to individuals in rural and underserved communities (Abubakar & Yusuf, 2023). These programs offer training in basic computer skills, internet navigation, and the use of productivity tools such as word processors and spreadsheets, thereby enhancing participants' employability and educational outcomes.

The impact of digital literacy programs in low-income communities can be transformative. According to a study by Omoregie and Eze (2023), individuals who participated in digital literacy training reported improvements in their academic performance, job prospects, and overall wellbeing. These programs have been shown to increase access to online learning platforms, improve job search skills, and enhance the ability to communicate with others through social media and email. Furthermore, digital literacy empowers individuals to access important health information, participate in civic activities, and engage in the digital economy. By equipping marginalized individuals with the necessary skills, digital literacy programs have the potential to reduce poverty, improve educational outcomes, and promote social inclusion (Musa & Okeke, 2024). Despite the growing awareness of the need for digital literacy programs, interventions in communities like Government Day Junior Secondary School Tanke have often been insufficient and poorly targeted. Key issues such as unreliable electricity, inadequate internet connectivity, and the absence of tailored training programs have hindered the success of these initiatives. Moreover, most digital literacy interventions are concentrated in urban centres, leaving underserved communities like Government Day Junior Secondary School Tanke further marginalized. This lack of equitable access exacerbates existing socio-economic disparities, making it difficult for residents to bridge the gap and benefit from digital inclusion. These limitations underscore the urgent need for inclusive, locally adaptable, and competency-aligned digital training programs that reflect both global best practices and national development priorities.
In response to these challenges, this study implemented and evaluated a digital literacy training initiative tailored for junior secondary school students at Government Day Junior Secondary School, Tanke. The intervention aimed to address both access and capacity gaps by focusing on foundational digital skills and aligning the training content with the Nigeria National Digital Literacy Framework (NDLF). The NDLF, developed by the Federal Ministry of Communications, Innovation and Digital Economy in 2023, synthesizes elements of the UNESCO Digital Literacy Global Framework and the European Commission’s Digital Competence Framework for Citizens (DigComp 2.2). The framework is structured around six competence areas: (i) Devices and Software Operations; (ii) Information and Data Literacy; (iii) Communication and Collaboration; (iv) Digital Content Creation; (v) Safety; and (vi) Problem Solving. The competency areas are further streamlined into 23 specific competencies that can be taught across eight progressive proficiency levels (FMCDE, 2023).

The digital training administered in this study focused on four core areas: computer appreciation, operating system basics, internet navigation and safety, and digital communications. These areas map directly onto the foundational competencies outlined in the NDLF. For example, training in computer appreciation introduced students to the core functions of computing devices, in alignment with the Devices and Software Operations domain of the framework. This foundational competency empowers learners with basic operational fluency and confidence in using digital tools (Adeleke & Oloyede, 2021). Similarly, instruction on operating system basics enabled students to navigate file structures, manage basic settings, and interact with user interfaces providing skills essential for achieving the first level of digital autonomy as prescribed in the NDLF’s first competence area. Furthermore, the internet navigation and safety module addressed key components of both the Information and Data Literacy and the Safety domains, equipping learners with the ability to search for, evaluate, and safely interact with digital information and environments. This also aligns with global standards on responsible digital citizenship and cybersecurity (Okeke & Ozioma, 2020).

Training on digital communication tools such as email, messaging platforms, and collaborative applications fulfilled competencies within the Communication and Collaboration domain of the NDLF. These skills are critical for academic development, peer interaction, and long-term workforce readiness (ISTE, 2019). Additionally, students learned appropriate digital etiquette, fostering respectful and effective communication in online contexts. By embedding these competencies into junior secondary education, the study reinforces the strategic vision of the NDLF to empower every Nigerian with the digital literacy required to participate meaningfully in the digital economy. This approach not only enhances students' academic engagement but also contributes to their broader socio-economic empowerment. It further provides a scalable model for extending digital literacy initiatives to other underserved regions, thus promoting inclusivity and reducing digital inequity.

Figure 1 shows the breakdown of the different competencies and the proficiency levels as in the Nigeria National Digital Literacy Framework (NDLF).

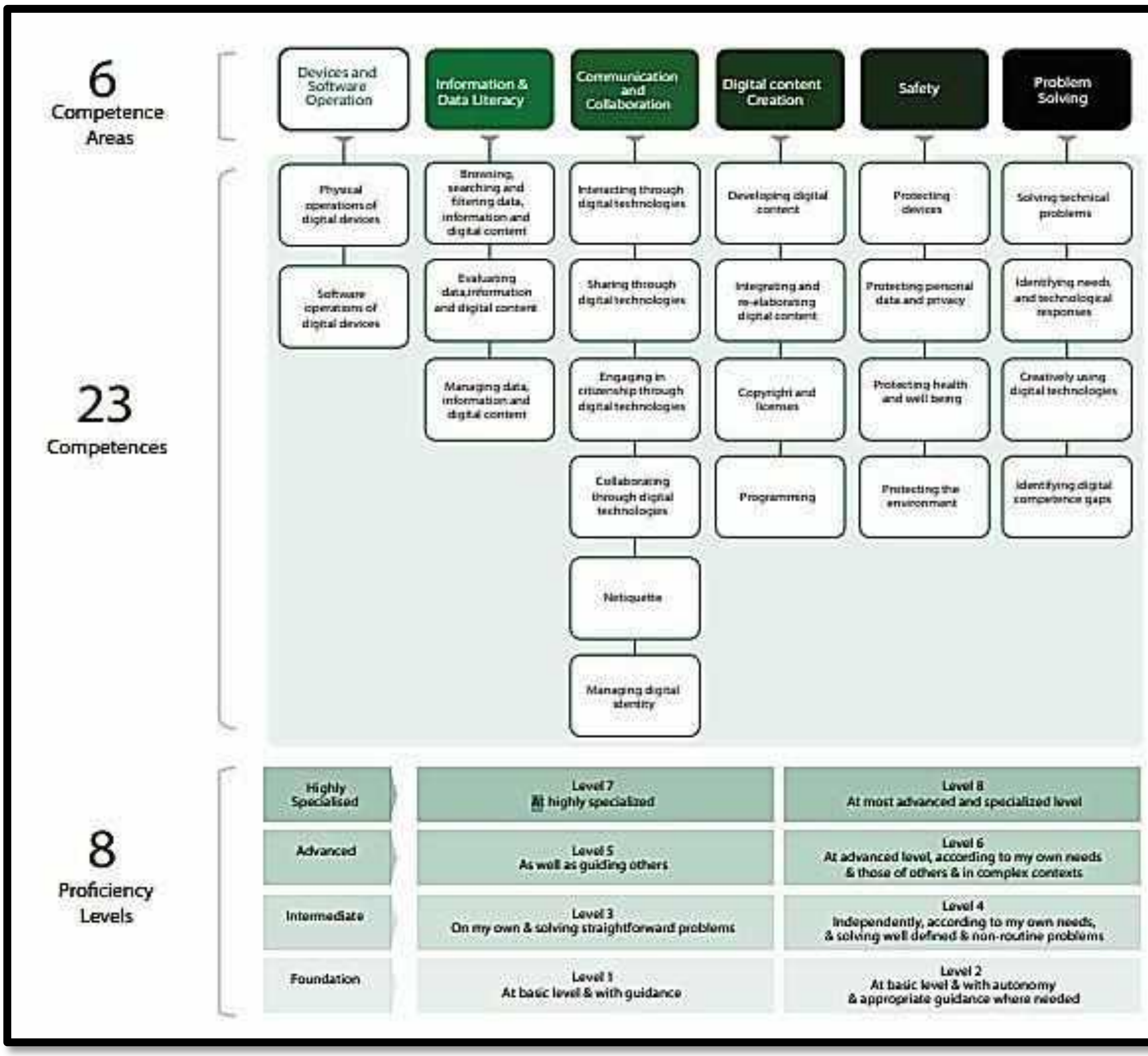

Figure 1: Nigeria National Digital Literacy Framework showing the Competence Areas

Source: Nigeria National Digital literacy Framework Document

Research Purposes

The objectives of the study were to:

(1) develop a digital literacy training package tailored to junior secondary learners,
(2) obtain expert assessments of the training content,
(3) implement the training program, and
(4) evaluate its effectiveness in enhancing students' digital competencies.

Methodology

This study employed a mixed-methods research design to assess the effectiveness of a digital literacy training programme among junior secondary school students at Government Day Junior Secondary School, Tanke, Ilorin, Kwara State, Nigeria. 100 JSS 3 students selected by the school formed the participants for the study. Quantitative data were collected using a researcher-designed Digital Literacy Skills Questionnaire (DLSQ), administered before and after the training to assess improvement in students' digital proficiency. Qualitative data were obtained through expert evaluations of the training package using an Expert Assessment Form (EAF), assessing criteria such as content accuracy, instructional effectiveness, and engagement. Data were analysed using descriptive statistics (mean scores and percentages) for the quantitative phase, while thematic analysis was used for qualitative responses from experts.

Results

Objective 1 - to develop a digital literacy training package tailored to junior secondary learners.

In Nigeria, the National Digital Literacy Framework (NDLF) was established to provide a strategic roadmap for embedding digital skills into formal education. Anchored in this framework, the training intervention in this study focused on developing and delivering digital literacy content tailored to Junior Secondary School (JSS) learners, centred on four core competencies: digital communication, computer appreciation, internet navigation and safety, and operating system basics. These competencies were not only contextually grounded but also developed following the ADDIE model of Analysis, Design, Development, Implementation, and Evaluation.

The ADDIE model was employed as a systematic guide for developing age-appropriate digital literacy training materials for JSS students. The analysis phase involved identifying the digital skill gaps among learners in Nigerian public schools and reviewing the NDLF’s basic digital skill domains (Federal Ministry of Communications and Digital Economy [FMCDE], 2023). The design and development phases emphasized the customization of instructional resources to suit cognitive levels, language proficiency, and the infrastructural realities of the participating Junior Secondary School.

The implementation phase involves instructional strategies that integrated task-based learning, visual instruction, and contextual simulations, ensuring that learners could engage meaningfully regardless of prior exposure. The digital communication component introduced students to foundational digital interaction tools such as email, chat applications, and digital collaboration platforms. Learning activities incorporated mock email writing, chat simulations, and netiquette scenarios using offline worksheets and role-plays. These were designed to help learners grasp the principles of digital interaction before engaging with real-time applications. Content design aligned with NDLF's requirement for basic digital communication skills and emphasized ethical and respectful online conduct (FMCDE, 2023).

In the computer appreciation module, learners were introduced to basic hardware and software concepts. Visuals such as color-coded diagrams, physical models of computer components, and simple identification activities helped simplify complex ideas. Instructional scaffolding moved students from recognizing familiar devices (smartphones and TVs) to understanding more advanced computing systems (desktops and laptops). The approach focused on functional appreciation, enabling students to identify device roles in everyday use. Operating system basics training materials focused on navigation of desktop environments with Windows OS, file management, and simple application operations. The lessons adopted progressive task modelling where the trainers first demonstrated procedures (e.g. opening folder, saving files, switching windows), followed by guided practice, then independent learner attempts.

The Evaluation phase of the ADDIE framework was carried out in stages. A formative evaluation was conducted during the development phase which involve reviews by ICT educators and field experts to validate content relevance, clarity, and pedagogical alignment. Feedback informed iterative refinement of materials to suit the learning pace and experience of JSS students. There was a summative evaluation that checked the participants feedback on the training programme and performance on the content learned during the training.

Objective 2- to obtain expert assessments of the training content

Table 1: Experts assessment of the developed training package

S/N	Content Accuracy and Relevance	mean	SD
1	The content aligns with digital literacy concepts and skills	3.40	.54
2	The information provided is accurate and to date	3.60	.54
3	The content is relevant to junior secondary students in rural areas	3.80	.44
	Mean score	**3.60**	
	Clarity and Organization		
1	The slides include interactive elements (e.g. questions, activities).	2.40	1.34
2	Visual (images, icons, infographics) enhance comprehension	3.20	1.30
3	The slides encourage participation and active learning	3.40	.89
	Mean score	**3.00**	
	Engagement and interactivity		
1	The slides include interactive elements (e.g. questions, activities).	2.40	1.34
2	Visual (images, icons, infographics) enhance comprehension	3.20	1.30
3	The slides encourage participation and active learning	3.40	.89
	Mean score	**3.00**	
	Instructional Effectiveness		
1	The slides align with instructional objectives	3.60	.54
2	The materials support diverse learning styles	4.00	.70
3	The content facilitates knowledge retention	4.00	.70
	Mean score	**3.86**	
	Technical Design and Aesthetics		
1	The slides use appropriate font size, colours, and contrast	3.60	.54
2	The layout is visually appealing without being distracting	4.00	.70
3	The use of animations and transitions is appropriate and excessive	3.20	.83

Mean score	**3.06**

Benchmark: 2.5

The expert rating of the digital literacy training materials designed for junior secondary school (JSS) students in rural areas reveals key strengths and areas for improvement across five instructional categories: content accuracy and relevance, clarity and organization, engagement and interactivity, instructional effectiveness, and technical design. Content Accuracy and Relevance received a high mean score of 3.60, indicating that the materials are accurate, up to date, and wellaligned with core digital literacy concepts. The highest-rated item under this category was the relevance of the content to rural JSS students (mean = 3.80), showing that contextualization was effectively achieved.

Clarity and Organization had a moderate mean score of 3.00, suggesting that while visuals like infographics (mean = 3.20) supported comprehension, the materials lacked strong interactive features. The low score for interactive elements (mean = 2.40) highlights a need for more structured, learner-engaging components. Similarly, Engagement and Interactivity also recorded a mean score of 3.00. Experts pointed out that while visuals were helpful, the lack of consistent interactive content limited opportunities for participation and active learning. This calls for improvements using tools such as questions, quizzes, or simple games to foster learner involvement.

In contrast, Instructional Effectiveness received the highest mean score of 3.86, with particularly strong ratings for supporting diverse learning styles and enhancing knowledge retention (mean = 4.00). This shows the materials were effective in meeting learning objectives and accommodating varied learner needs. Technical Design and Aesthetics scored 3.06, reflecting acceptable use of fonts, layout, and colours. However, the use of animations and transitions (mean = 3.20) was seen as potentially excessive or unnecessary. Refining these elements can enhance user experience without distracting from content delivery. Overall, the materials are pedagogically sound, particularly in content quality and instructional value. To further enhance usability and engagement, the inclusion of more interactive elements and refined visual design is recommended.

Objective 3: to implement the training program

The implementation of the digital literacy training programme at Government Day Junior Secondary School, Tanke, Ilorin, adopted a systematic and pedagogically sound approach. Initially, a letter of introduction was obtained from the Head of Department to formally seek permission from the management of the selected junior secondary school. Upon receiving approval, a mutually convenient date was proposed and confirmed for the implementation of the digital literacy lesson. Prior to delivery, logistical arrangements were made, including scheduling sessions during nonacademic hours, preparing hall to accommodate use of digital devices, securing internet access, and orienting facilitators. The Junior Secondary School selected 100 out of their JSS3 students to participate in the training. Students were briefed on the purpose, structure, and expectations of the programme to enhance readiness and motivation. On the agreed date, the instructional session was conducted with active student participation. The learners demonstrated enthusiasm and engagement throughout the training. At the conclusion of the session, a structured set of assessment questions was administered to evaluate students' comprehension and retention of the digital literacy concepts delivered during the lesson.

Objective 4: evaluate its effectiveness in enhancing students' digital competencies.

In order to determine the effectiveness of the digital literacy training on the Junior Secondary School student, the evaluation was carried out on two levels – the reaction and the performance test in digital literacy skills.

Table 2: Students' reaction towards the digital literacy program

S/N	Item	Mean	SD
1	I enjoy learning digital skills as part of my school program.	3.71	.60
2	The digital literacy program has improved my confidence in using computers.	3.32	.61
3	I find it easy to navigate and use digital tools introduced in the program.	2.76	1.20
4	Learning digital skills will help me in my future education and career.	2.75	.92
5	I believe digital literacy is as important as other school subjects.	3.05	1.06
6	The teaching methods used in the digital literacy program make learning fun.	3.51	.70
7	I feel comfortable using digital devices (e.g., computers, tablets, smartphones) for schoolwork.	3.09	.73
8	I actively participate in digital literacy classes.	2.33	1.05
9	I think digital skills will help me perform better in other subjects.	2.60	.93
10	The school provides enough resources for learning digital skills.	2.91	1.02
	Mean score	**3.00**	

Benchmark: 2.5

The students' responses to the digital literacy program, as presented in Table 2, indicate a generally positive attitude toward the initiative, with a composite mean score of 3.00, suggesting moderate agreement across the evaluated items. Notably, the highest mean score (M = 3.71, SD = .60) was recorded for the item "I enjoy learning digital skills as part of my school program," highlighting the program's appeal and relevance to students' interests. Similarly, items related to confidence in using computers (M = 3.32, SD = .61) and the fun and engaging nature of the teaching methods (M = 3.51, SD = .70) suggest that the instructional approach successfully fostered a supportive and motivating learning environment.

However, lower mean scores were observed in areas concerning the ease of navigating digital tools (M = 2.76, SD = 1.20), perceived utility in other school subjects (M = 2.60, SD = .93), and student participation (M = 2.33, SD = 1.05). These scores imply that while enthusiasm exists, practical challenges in digital skill application and student engagement persist. Furthermore, perceptions regarding institutional support — specifically, resource adequacy (M = 2.91, SD = 1.02) — fell below the ideal benchmark, underscoring a need for improved infrastructure and access to digital learning tools.

Table 3: Students performance in Digital Literacy test questions

S/N	Items	Mean	SD
	Introduction to Computer		
1	What is the primary function of a computer	3.82	.64
2	Which of the following is an input device	3.79	.57
3	What is the function of the Central Processing Unit	3.71	.67
4	What is an example of software	3.58	.87
5	Which of the following is not part of output devices	3.22	1.15
	Mean score	**3.62**	
	Operating System		
1	What is the primary function of an operating system	3.49	1.02
2	What is the first step in the booting process	3.26	1.00
3	Why is it important to shut down a computer properly	3.47	1.00
4	Which of the following is not a word processing application	3.11	1.17
5	What is the purpose of a file management system	3.70	.68
	Mean score	**3.40**	
	Internet Navigation and Safety		
1	Which of the following is a safe internet browsing practice	3.61	.95
2	What is a recommended way to protect yourself from phishing scams	3.38	1.11
3	What is an effective way to use search engines efficiency	3.47	1.02
4	How can you enhance password security	3.57	.89
5	What should you do before making a purchase from unfamiliar website	3.42	1.12
	Mean score	**3.49**	
	Digital Communication		
1	Which of the following is not a type of digital communication	3.49	1.01
2	What is one key benefit of digital communication	3.69	.82
3	Which of the following is a principle of effective digital communication	3.60	.92
4	What is an example of proper digital communication etiquette (netiquette)	3.16	1.17
5	What is the final step in creating an email account	3.23	1.12
	Mean score	**3.43**	

The post-test results in Table 3 shows detailed insight into students' understanding of the digital literacy content taught across four thematic areas: Introduction to Computers, Operating System, Internet Navigation and Safety, and Digital Communication. The highest mean performance was observed in the Introduction to Computers section (M = 3.62), indicating a strong grasp of foundational concepts such as the functions of a computer (M = 3.82, SD = .64), identification of input devices (M = 3.79, SD = .57), and understanding the role of the Central Processing Unit (M = 3.71, SD = .67). These high scores suggest that learners retained core knowledge effectively, possibly due to the concrete and tangible nature of the concepts introduced early in the program.

In the Internet Navigation and Safety domain, students also demonstrated commendable understanding, with a mean score of 3.49. Items such as safe browsing practices (M = 3.61, SD = .95) and password security enhancement (M = 3.57, SD = .89) received relatively high ratings, suggesting an increased awareness of online safety which is a critical digital literacy outcome.

The Digital Communication component yielded a slightly lower mean score (M = 3.43), with students performing well on identifying communication types and principles (M = 3.60, SD = .92) and recognizing benefits of digital communication (M = 3.69, SD = .82). However, items on digital etiquette (M = 3.16, SD = 1.17) and procedural tasks such as email account setup (M = 3.23, SD = 1.12) showed moderate understanding, possibly indicating the need for more practicebased instruction in these areas.

Finally, the Operating System domain recorded the lowest average mean (M = 3.40), although students showed good comprehension of file management systems (M = 3.70, SD = .68) and system shutdown procedures (M = 3.47, SD = 1.00). Items involving technical steps in system operations (e.g., booting process: M = 3.26, SD = 1.00) were less well-understood, reflecting a general trend that learners may struggle with abstract or less visually engaging content.

Overall, the post-test data suggests that the digital literacy training was effective in enhancing learners' knowledge across core areas, with particularly strong outcomes in foundational computer knowledge and internet safety. Continued emphasis on practical applications and reinforcement of technical concepts is recommended to consolidate learning in areas where comprehension was relatively weaker.

Conclusion and Recommendation

This study evaluated students' reactions to and post-test performance in a digital literacy program designed to enhance foundational ICT competencies among school-aged learners according to the national Digital Literacy Framework. The findings reveal a generally positive disposition towards digital learning, with students expressing enjoyment and confidence in learning digital skills. The post-test results further affirmed the effectiveness of the program, with mean scores across key domains ranging from moderate to high. These outcomes demonstrate that structured and context-relevant digital literacy interventions can significantly improve students' knowledge and attitudes toward digital technologies, especially when aligned with engaging pedagogical strategies. Despite the overall success, areas such as practical application of operating system functions and digital communication etiquette showed room for improvement. The variability in standard deviations also points to differing levels of prior exposure and familiarity among students, suggesting the need for differentiated instruction.

Based on the findings, it is recommended that the digital literacy program be enhanced through increased practical engagement using hands-on activities and real-life digital tasks to improve students' skill application. A tiered learning approach should be adopted to cater to diverse learner proficiency levels, while continuous capacity building for instructors is essential to ensure effective and engaging delivery. Schools should also invest in expanding access to digital infrastructure and resources to support equitable learning. Furthermore, future studies should monitor the long-term impact of digital literacy acquisition on students' academic performance, employability, and responsible digital citizenship to inform continuous program improvement

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ADAPTIVE LEARNING SYSTEMS: Tailoring Education with AI

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Abstract
Education has undergone significant transformation with the rise of technology, particularly Artificial Intelligence (AI), which is reshaping traditional instructional models. Adaptive Learning Systems leverage AI to personalize learning experiences through tailored content delivery, feedback, and pacing based on individual student needs. Grounded in key theoretical frameworks, this paper examines the functionality, evolution, and educational impact of AI-powered adaptive systems. It reviews current literature, explores the role of AI in personalizing education, and addresses the challenges associated with implementation, such as data privacy and algorithmic bias. The study also outlines future directions and offers practical recommendations for educators and system designers to enhance the effective use of adaptive learning technologies.
***Keywords**:* Adaptive Learning System, Artificial Intelligence, Personalized Education, Traditional Learning, EdTech

Introduction

Adaptive learning is transforming modern education by leveraging Artificial Intelligence (AI) to create personalized learning experiences. This innovative approach employs data-driven instruction that dynamically adjusts to the unique needs of each student, offering a tailored and flexible educational model. By utilizing AI, adaptive learning systems can continuously monitor student progress, engagement, and performance, making real-time modifications to content delivery, pacing, and instructional strategies (Johnson et al., 2020).

While education has long been a foundational pillar of societal development, traditional instructional models often follow a one-size-fits-all approach. Such models typically fail to accommodate the diverse learning styles, paces, and abilities of students. As a result, some learners excel while others fall behind due to mismatches between instructional delivery and individual learning preferences. Adaptive learning systems, powered by AI, aim to bridge this gap by offering responsive and personalized educational experiences that adjust in real time to learners' evolving needs and capabilities.

Adaptive learning systems refer to intelligent platforms and tools that adjust instructional content based on a learner’s behavior, progress, and performance. Through continuous analysis of learner-system interactions, these platforms modify the pace, structure, and type of content presented to optimize the learning journey. This level of personalization ensures that each student receives instruction aligned with their current level of understanding, thereby enhancing engagement and knowledge retention.

Recent advancements in AI have accelerated the effectiveness and accessibility of adaptive learning technologies. These systems now leverage sophisticated algorithms capable of processing vast amounts of data in real time, allowing for granular adjustments to learning pathways and difficulty levels. By dynamically responding to learner feedback and performance, adaptive platforms improve instructional efficiency and effectiveness; positioning education to better meet the evolving demands of the 21st-century learner.

In contrast to traditional educational models that deliver uniform content regardless of student readiness, adaptive systems create individualized learning paths. These paths are continuously updated, fostering deeper engagement and improved academic outcomes. Empirical evidence supports the efficacy of adaptive learning. For example, Pane et al. (2014) conducted a large-scale study in mathematics education and found that students who engaged with adaptive learning platforms significantly outperformed their peers in traditional classroom settings. Their research highlights that adaptive systems are particularly beneficial in sequential subjects, where mastering one concept is foundational to understanding the next.

Overall, adaptive learning systems offer numerous advantages over traditional instruction, including enhanced personalization, increased engagement, improved learning outcomes, and greater scalability. These features make adaptive learning a promising approach for modernizing educational practices in a rapidly evolving digital age.

Literature Review

This section presents a review on related studies in the literature under the following sub-headings:

i. Theoretical Framework
ii. AI Role in Personalizing Education
iii. Evolution of Adaptive Learning Systems

i. Theoretical Framework

This study is grounded in four interrelated theoretical perspectives: Constructivist Learning Theory, Personalized Learning Theory, the Artificial Intelligence in Education (AIED) Framework, and Cognitive Load Theory. Together, these frameworks provide a comprehensive foundation for understanding the design, implementation, and evaluation of AI-powered adaptive learning systems.

Constructivist Learning Theory, posits that learners actively construct knowledge through engagement and interaction with their environment. Adaptive learning systems embody this theory by adjusting instructional content to match each learner’s current level of understanding, thereby promoting self-paced learning. These systems also support scaffolding within Vygotsky’s Zone of Proximal Development (ZPD), offering just-in-time support to help learners progress to higher levels of mastery (Johnson, 2017; Luckin et al., 2016).

Personalized Learning Theory emphasizes the importance of tailoring education to individual learners’ needs, interests, and capacities. Adaptive systems operationalize this theory by leveraging AI to analyze learner data such as performance metrics and engagement patterns and deliver instruction that is appropriately challenging and responsive (Pane et al., 2014; Johnson, 2017; Luckin et al., 2016). This individualized approach has been shown to enhance student motivation, engagement, and learning outcomes.

The Artificial Intelligence in Education (AIED) Framework focuses on the integration of advanced technologies such as machine learning, predictive analytics, and natural language processing into educational environments. These technologies enable real-time adaptation of content, intelligent tutoring, and personalized feedback, thereby creating dynamic and responsive learning experiences (Woolf, 2010; Luckin & Cukurova, 2019; Johnson, 2017). The AIED framework provides the technical rationale for how adaptive learning systems function and evolve.

Cognitive Load Theory addresses the limits of working memory during the learning process. It emphasizes the importance of minimizing extraneous cognitive load while optimizing intrinsic and germane load. Adaptive learning platforms apply this theory by sequencing content strategically, reducing unnecessary complexity, and presenting materials in manageable formats. This helps learners retain information more effectively, especially in subjects that require sequential learning, such as mathematics (Luckin et al., 2016; Pane et al., 2014).

Collectively, these theoretical frameworks inform the pedagogical and technological underpinnings of adaptive learning systems, guiding their development and evaluating their potential to improve educational outcomes.

ii. Evolution of Adaptive Learning Systems

Adaptive learning originated in the 1970s and 1980s with rule-based systems that offered limited personalization and required manual updates. With the advent of AI technologies such as machine learning, data analytics, and neural networks. Modern adaptive systems have become far more sophisticated, capable of real-time, personalized content delivery. Early intelligent tutoring systems laid the foundation for these advancements but, they often required manual updates and lacked the scalability and real-time responsiveness that characterize today's AI-enhanced platforms (Woolf, 2010).

iii. AI Role in Personalizing Education

AI is the driving force behind adaptive learning systems. Through machine learning, data analytics, and predictive algorithms, AI monitors students' learning behaviors, identifies areas of strength and weakness, and adjusts instructional strategies accordingly. AI's ability to process large volumes of data allows adaptive learning systems to identify patterns that may not be immediately visible to educators. This continuous feedback loop enhances learning by personalizing the experience and addressing gaps in knowledge as they arise.

AI also supports various components of adaptive learning, such as predictive assessments, content recommendation, and real-time feedback. It enables systems to predict when a learner might struggle and suggests interventions, including supplementary content or alternative learning strategies. By adapting to a learner's progress, AI allows education to become more flexible and inclusive.

In more recent literature, AI's role in making education self-paced has been widely discussed. Johnson (2017) emphasizes the importance of AI in identifying learning patterns and providing feedback to both students and teachers. By collecting data on student behavior, AI can predict the areas where a student is likely to struggle and provide customized interventions. These insights allow educators to focus their attention on areas that require the most support, improving overall teaching efficiency.

Luckin et al. (2016) provide a comprehensive overview of how AI can be used to create personalized learning environments. They suggest that adaptive learning systems can increase student motivation and engagement by offering challenges that are neither too easy nor too difficult. This idea is supported by findings from studies on cognitive load theory, which suggest that learners perform best when content is pitched at an optimal level of difficulty.

Previous researches affirms the potential of Adaptive Learning Systems to enhance educational outcomes by providing personalized, efficient, and engaging learning experiences. However, there are also significant ethical and practical considerations that need to be addressed.

AI Model Evaluation

This section examines the core algorithms that power adaptive learning systems, with particular emphasis on their accuracy, adaptability, and scalability. Effective evaluation of these algorithms requires rigorous testing on diverse datasets to ensure they perform reliably across a wide range of learner backgrounds, abilities, and learning styles.

In addition to technical performance, the fairness and transparency of AI decision-making must be critically assessed. Ethical considerations such as algorithmic bias and the opacity of automated instructional decisions demand ongoing scrutiny to uphold trust and accountability in educational contexts.

Furthermore, adaptive learning systems must proactively address issues of equity and access. It is essential to ensure that all students, regardless of socioeconomic status, can benefit from personalized learning technologies. Inclusivity should be a guiding principle in both the design and implementation of AI-powered educational tools.

Things to consider when adopting Adaptive Learning Platforms

Choosing an adaptive learning platform involves several critical factors to ensure it meets the training needs effectively. Here are key considerations:

1. Defining Training Goals: Clearly outlining the objectives of your training program and determining what skills or knowledge the learners want to acquire and how adaptive learning can help achieve these specific goals. This clarity will guide the choice of platform features that align with the clearly stated objectives.
2. Understanding the Audience or User: Analyzing the characteristics of the target audience, including their learning styles, preferences, and prior knowledge. A platform that offers personalized learning paths based on user profiles can enhance engagement and effectiveness.
3. Scalability: Ensuring the platform can accommodate a growing number of users without compromising the quality of learning experiences. Scalable platforms allow for simultaneous access by multiple learners while maintaining personalized content delivery.
4. User-Friendly Interface: Selecting a platform with an intuitive interface that facilitates easy navigation for both learners and administrators. A user-friendly design enhances engagement and reduces barriers to effective learning.
5. Cost and ROI: Evaluating the cost-effectiveness of the platform in relation to its features and potential return on investment. Considering both direct costs and the long-term benefits of improved learner outcomes and retention rates.
6. Security and Compliance: Ensuring the platform adherence to relevant data protection regulations and industry standards. This includes safeguarding user data and ensuring compliance with educational guidelines to protect both learners and organizations.

Some Adaptive Learning Platforms are; Pearson, RealizeIt, 360 Learning, Axonify, Adaptemy, Knewton, EdApp, RiseUp, CogBooks, Smart Sparrow, CYPHER Learning, OttoLearn, LearnUpon, ScootPad, Gyde, e.t.c.

Challenges and ethical consideration

Adaptive Learning Systems have emerged as powerful tools for personalizing education, yet they come with a range of challenges and ethical considerations that must be addressed to ensure their effective and responsible use.

One of the primary challenges associated with adaptive learning systems is data privacy and security. These platforms require extensive data collection, including personal and behavioral information from users.

The widespread use of AI in education raises questions about who owns the data generated by students and how it is used. Additionally, biases in AI algorithms can reinforce existing inequalities particularly if the data used to train these systems is not representative of diverse populations (Holmes and Luckin, 2018).

This reliance on data raises significant concerns about potential data breaches and unauthorized access, making it essential for organizations to adhere to stringent regulations like the General Data Protection Regulation (GDPR) and the Health Insurance Portability and Accountability Act (HIPAA) to protect sensitive information (Brown, 2024).

Another critical issue is algorithmic bias. Adaptive learning systems can inadvertently perpetuate biases present in their training data, which may lead to unfair treatment of specific groups of learners. To combat this challenge, educational institutions must implement continuous monitoring and conduct algorithm audits to identify and mitigate potential discrimination (Agarwal et al., 2023).

Additionally, the transparency and accountability of these systems pose significant challenges. The opaque nature of artificial intelligence (AI) decision-making can complicate efforts to trace accountability for errors or biased outcomes. Establishing clear guidelines regarding who is responsible when AI systems fail or produce inequitable results is crucial to maintaining trust in these technologies (Miao et al., 2021).

In terms of ethical considerations, informed consent is paramount. Users must be fully informed about data collection practices and how their information will be utilized. A lack of transparency in these processes can lead to mistrust among users, undermining the effectiveness of adaptive learning systems (Chan, 2023). Ensuring equity and accessibility in adaptive learning technologies is essential. Disparities in access can exacerbate existing educational inequalities, making it vital for educators and institutions to strive for inclusive solutions that benefit all learners (Zajko, 2021).

The integration of Adaptive Learning may impact the role of educators, raising questions about their authority and the nature of teacher-student relationships. As technology takes on more personalized instructional roles, it is important to consider how this shift might affect the dynamics within educational environments (Slade & Prinsloo, 2013).

In conclusion, while adaptive learning systems hold great promise for enhancing personalized education, addressing the associated challenges and ethical considerations is crucial for their successful implementation.

The Future of Adaptive Learning

The future of adaptive learning is likely to be characterized by further integration of advanced AI technologies such as deep learning, natural language processing, and predictive analytics. These technologies will enable even more sophisticated personalization, allowing adaptive learning systems to not only adjust content but also engage in more human-like interactions with students. As AI becomes more advanced, systems will be able to interpret student emotions, gauge motivation levels, and provide feedback that is more tailored to individual student needs (Luckin and Cukurova, 2019).

Furthermore, adaptive learning will become more prevalent in classrooms worldwide, transcending subject boundaries and moving beyond traditional academic subjects to include skills-based and professional training. The use of adaptive learning in lifelong learning and workforce development will also increase, providing personalized education throughout a person's career.

Ethically, the future of adaptive learning will involve addressing concerns related to data privacy and bias in AI algorithms. Ensuring that these systems are equitable and accessible to all students, regardless of socioeconomic background will be a key priority.

Conclusion

Adaptive learning systems represent a paradigm shift in education, driven by advances in AI. These systems provide personalized learning experiences that cater to the unique needs of each student, improving engagement and learning outcomes. AI plays a crucial role in the continuous assessment and adaptation of content, making education more flexible, efficient, and scalable.

While the potential benefits of adaptive learning systems are clear, challenges such as data privacy, algorithmic bias, and access to technology must be addressed to ensure that all students can benefit. As adaptive learning continues to evolve, it will likely become an essential tool for modernizing education and preparing students for the challenges of the future.

Recommendations

Based on the outcome of this study, the following recommendations are made;

1. Adaptive Learning System should be designed to support various media types (text, video, audio) to cater to different learning preferences and to enhance engagement.
2. Ensuring that Adaptive Learning Systems are more flexible in terms of scalability so as to accommodate large number of users and integrate seamlessly with existing educational technologies and standards.
3. Adaptive Learning System designers should explore on the integration of tools such as text-to-speech, subtitles, Virtual Reality(VR) and Augmented Reality (AR) to create immersive learning experiences that cater to practical applications of various fields.
4. Robust security measures should be implemented to protect students or users' data and compliance with privacy regulations.

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Attitude of Pre-service Teachers towards the Utilization of Podcast for Learning in Colleges of Education in Kwara State, Nigeria

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Abstract

Podcasts, which are digital audio files available for download or online streaming, provide students with the flexibility to access educational content at their convenience. Although podcasting has potential benefits for education, its implementation in colleges of education in Kwara State, Nigeria remains relatively sparse. This limited use can be attributed to several challenges, including: lack of awareness, insufficient infrastructures, and limited technical skills (Muhammad et al., 2013). Hence, the study examined Attitude of Pre-service Teachers to the Utilixation of Podcast for Learning in Colleges of Education in Kwara State. The objectives of this study were to: (i) Investigate the current attitude of pre-service teachers in colleges of education in Kwara State towards the integration of podcast as a pedagogical tool in their learning experiences (ii) Identify the factors influencing pre - service teachers' attitude toward the use of podcast for learning in colleges of education in Kwara State, Nigeria. This study adopted a descriptive research design of the survey type. Random sampling technique was adopted to select 200 pre-service teachers from colleges of education in kwara state, two research questions and one hypothesis raised were tested at 0.05 level of significance. Data collected using a researchers' designed questionnaire were analyzed using descriptive and inferential statistics, mean and standard deviation, One-way Analysis of Variance (ANOVA) for hypotheses. The validity of the instrument was done through face and content validity. The Findings of the study were: that attitude of students towards the use of podcast for learning was positive; perceived ease of use, perceived usefulness for learning specific subjects with podcast was positive; technical challenges, access to necessary technology and internet connectivity, and the influence of instructors' perspectives on podcast integration was negative; there is no significant difference between attitude of pre-service teachers towards podcast use and their perceived self-efficacy in utilizing technology for teaching – learning process. The study concluded that the attitude of pre-service teachers towards the utilization of podcast for learning was positive, and no significant difference between attitude of pre-service teachers towards podcast utilization and their perceived self-efficacy in utilizing technology for teaching – *learning process. It was suggested that prospective teachers, no matter their gender or where they live, become highly proficient in using podcasts as a learning tool.*

Introduction

The landscape of teacher education is constantly evolving, driven by advancements in technology and a growing understanding of effective pedagogical practices. In this dynamic environment, the integration of digital tools has become increasingly significant in preparing future educators. These technologies offer novel avenues for delivering content, fostering engagement, and cultivating essential 21st-century skills among pre-service teachers (UNESCO, 2023).

Among the burgeoning digital resources available, podcasts have emerged as a versatile and accessible medium with the potential to enrich the learning experiences of teacher trainees. Characterized by their episodic audio format, podcasts offer flexibility in learning, allowing students to access educational content anytime and anywhere (Anderson & Rainie, 2020). They can deliver lectures, interviews with experts, discussions on pedagogical approaches, and even real-world classroom scenarios, providing a rich and varied learning environment beyond the traditional lecture hall (Levin & Trostel, 2017).

The theoretical underpinnings for exploring the use of podcasts in education are rooted in constructivist learning theories, which emphasize active engagement and the construction of knowledge by the learner (Piaget, 1971; Vygotsky, 1978). Podcasts can facilitate this by allowing pre-service teachers to revisit content, reflect on discussions, and integrate new information at their own pace. Furthermore, the portability and on-demand nature of podcasts align with principles of flexible and personalized learning, catering to diverse learning styles and schedules (Ally, 2004).

In the Nigerian context, and specifically within Colleges of Education in Kwara State, the adoption of technology-enhanced learning approaches is gaining momentum. These institutions play a crucial role in shaping the next generation of teachers who will, in turn, influence the quality of education at the primary and secondary levels. Understanding the perceptions and attitudes of these pre-service teachers towards innovative tools like podcasts is therefore paramount. Their disposition towards such technologies will significantly impact their willingness to embrace and effectively utilize them in their future classrooms (Ertmer, 2005).

However, the integration of podcasts into teacher education programs is not without potential challenges. Factors such as access to technology, digital literacy levels of both instructors and students, and the perceived value and ease of use of podcasts can influence their adoption and effectiveness (Venkatesh & Davis, 2000). This study aims at understanding pre-service teachers' perspectives on using podcasts within Colleges of Education in Kwara State is crucial to identify potential barriers and facilitators for successful implementation.

This study, therefore, seeks to examine the attitudes of pre-service teachers in Colleges of Education in Kwara State towards the use of podcasts as a learning tool. By understanding their perceptions, this research aims to provide valuable insights for educators, curriculum developers, and policymakers in Kwara State and beyond, informing decisions regarding the strategic integration of digital resources like podcasts to enhance the quality of teacher education and ultimately contribute to a more technologically proficient teaching workforce.

Purpose of the Study

The main purpose of this study was to find out attitude of pre-service teachers towards the use of podcast for learning in colleges of education in Kwara State, Nigeria.

Specifically, the study would seek to:

1. Examine the current attitude of pre-service teachers in colleges of education in Kwara State towards the integration of podcast as a pedagogical tool in their learning experiences

2. Identify the factors influencing pre - service teachers' attitudes toward the use of podcast for learning in colleges of education in Kwara State, Nigeria.

Research Questions

The following questions were raised and answered;

1. What is the current attitude of pre-service teachers in colleges of education in Kwara State towards the integration of podcast as a pedagogical tool in their learning experiences?
2. What are the factors influencing pre - service teachers' attitudes toward the use of podcast for learning in colleges of education in Kwara State, Nigeria?

Research Hypotheses

H_{01}: There is no significant difference between attitude of pre-service teachers towards podcast use and their perceived self-efficacy in utilizing technology for teaching and learning in colleges of education in Kwara State

Review of Related Literature

The Role of ICT in the Conduct of Teaching and Learning in Nigeria Schools

The teaching and learning of History in the Nigerian institutions most importantly in the 21st century have developed within the framework of theory and practice. In this technological age, the effective means of communication in the classroom instruction requires the use of communication technologies. "The illiterate of the 21st century, will not be those who cannot read and write, but those who cannot learn, unlearn, and re-learn." Alvin Toffler (cited in Shikshak, 2009).

The above statement pointed out the relevance of ICT revolution in the 21st century education. Haddad and Jurich, (2017) argued that there are four basic issues in the use of ICTs in education in the 21st century. They are effectiveness, cost, equality and sustainability. They pointed out that, in recent years, there has been an upsurge of interest in how ICTs most importantly computers and the internet can best be harnessed to improve the efficiency and effectiveness of education at all levels and in both formal and non-formal settings (Haddad and Jurich, 2002). The role of ICT in the teaching and learning of History in the 21st century can be seen in four major angles namely, the impact on teacher, learner and the image of history as a discipline. Conventional teaching which is still common today in our schools emphasizes content. For many, teachers of history in particular have taught through lectures and presentations interspersed with tutorials and learning activities designed to consolidate and rehearse the content (Kamal and Banu, 2010).

Meanwhile, contemporary settings are now favoring curricula that promote competency and performance. In the developed countries, curricula are starting to emphasize capabilities and to be concerned more with how the information will be used than with what the information is. The moves to competency and performance-based curricula are well supported and encouraged by emerging instructional technologies (Stephenson, 2001). Such curricula tend to require: access to a variety of information sources; access to a variety of information forms and types; student-centered learning settings based on information access and inquiry; learning

The Concept of Podcast in Education

Podcast is an audio or visual content that is automatically delivered over a network via free subscription. Once subscribed to, podcasts can be regularly distributed over the Internet or within your school's network and accessed with an iPod, or any portable MP3 player, laptop, or desktop computer. Podcasts were originally audio-only but may now contain still images, video, and chapters identifying major sections or ideas. A podcasting is a method for distributing any digital media file (podcast), or series of files, over the Internet for playback on portable media players, such as iPods, and personal computers. Podcasting stands for Portable on Demand Broadcasting. The podcasting process begins with the creation of content through the use of audio capturing and editing tools. The subscription process of podcasting relies on the use of Really Simple Syndication (RSS) technologies.

The content provider acknowledges the existence of the created file by referencing it in an RSS enabled web site. The feed lists the locations of all episodes of a podcast, including episode publish dates, titles, and accompanying text descriptions. A user subscribes to a podcast by entering the permanent feed location into an aggregator program that reads RSS, such as Apple iTunes. Once subscribed, new podcast episodes are automatically delivered to the user's computer. The downloaded episodes can then be played, replayed, or archived as with any other computer file.

According to Lim (2006) pod-casting involves "the authoring of, and subscription to, audio and/or video files on the internet for downloading to the user's personal computer". Furthermore, pod-casting "enables users to quickly and easily download multimedia files, including audio and video, for playback on mobile devices". Kaplan – Leiserson (2005) define pod-casting as an Internet based service that allows subscription and downloading of digital audio contents (podcasts) by the means of the RSS technology, whereby these contents are transferred into an on-line repository or to a corresponding base in the computer, in the form of a data file. These can be accessed through different digital audio devices, including desktop computers.

Methodology

This study used a descriptive survey approach to examine pre-service teachers' attitudes toward using podcasts for learning in Colleges of Education. The population for this research comprised of all pre-service teachers in state colleges of education in Kwara State, Nigeria. Random sampling techniques was used to select 200 pre-service teachers. The researchers designed a questionnaire to elicit data from the respondents. The instrument was divided into three sections; Section A, B, and C. Section A contained information on the demographic information of the responds such as gender, area of specialization. Section B contained current attitudes of pre-service teachers in colleges of education in Kwara State towards the integration of podcast as a pedagogical tool in their learning experiences. Section C contained the information on factors influencing pre – service teachers' attitudes toward the use of podcast for learning. The four-point type of scoring consisted Strongly Agree which has 4 points, Agree 3 points, Disagree 2 points and Strongly Disagree 1 point.

Their corrections and suggestions were used to modify the Instrument. The researchers employed service of research assistants to admini

ster the instrument to the respondents and retrieve the completed questionnaire for further analysis. Data collected was analyzed using Descriptive and Inferential Statistics. Mean and Standard deviation was used to analyze research questions. Hypothesis was tested using independent t-test. Hypothesis was tested at 0.05 level of significance.

Results

They will not be deterred from any job by the need to use ICT tools. This was reflected in a mean score of 3.27 which revealed that the podcast helps them to develop cognitively in my study. Podcast are not always available for learning and that the use of Podcast makes it easier to learn in the school with mean score of 3.22 and 3.20 respectively. Podcast promotes teachers and students' participation in the school. It can then be inferred that attitude of pre-service towards the use of podcast for learning is positives. There is no significant difference between attitude of pre-service teachers towards podcast use and their perceived self-efficacy in utilizing technology for teaching and learning in colleges of education in Kwara State {F (2, 198) = 1.62, p= .20}. That is, the significance value (.20) was found to be greater than the alpha value (0.05). This means that the stated null hypothesis was accepted. By implication, the null hypothesis was established thus: no significant differences in attitude of pre-service teachers towards podcast use and their perceived self-efficacy in utilizing technology for teaching – learning in colleges of education in Kwara State

Summary of Major Findings

The findings of this study based on the research questions and the hypotheses formulated were summarized as follow:

1. that attitude of pre-service teachers towards the use of podcast for was positives.
2. there is no significant difference between attitude of pre-service teachers towards podcast use and their perceived self-efficacy in utilizing technology for teaching – learning in colleges of education in Kwara State

Discussions on Research Findings

Research question 1 sought to find out whether the attitude of pre-service teachers towards using podcasting will be positive or otherwise. The result of the mean value showed that the responses of the respondents were on the positive side. This meant that the tendency of the pre-service teachers to welcome the innovation of using podcast in learning was high.

In support of this finding, (Abubakar, Ogunlade, & Ibrahim, 2024; Wananyo, Ebi, & Ibi, 2024; Oladayo & Oladayo, 2024) show that teachers and lecturers in Nigeria generally hold positive attitudes towards the integration of Information and Communication Technology (ICT) and innovative technologies in teaching and learning. This aligns with Olumorin's (2008) finding of positive attitudes.

While not as prominent as infrastructural issues in recent studies, the idea of "resistance to change" (from traditional methods to technology-driven ones) is still acknowledged as a factor, often linked to lack of confidence or unfamiliarity (Ogoazu & Owojinjin, 2020)

From the findings, it could be deduced that there is general positive attitude towards technology integration among educators, although there is also persistent practical challenges (infrastructure, training) that can hinder actual implementation. The integration of social media for learning is indeed seen as beneficial and increasingly utilized, but with a clear understanding of the distractions it can pose and the critical need for comprehensive stakeholder efforts to ensure its effective and responsible use.

Conclusion

The findings in the research established that pre-service teachers had a positive attitude towards using podcast for learning. Moreover, there was no significant difference between attitude of pre-service teachers towards podcast use and their perceived self-efficacy in utilizing technology for teaching and learning in colleges of education.

Recommendations

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

1. government should provide the necessary assistance on the procurement of all needed podcast facilities. This could be in form of free excise duty, subsidizing the prices and free supply of the facilities into colleges of education. This will encourage all prospective teachers to embrace the adoption of podcast utilization;
2. prospective teachers, no matter their gender or where they live, become highly proficient in using podcasts as a learning tool;
3. government and policy makers in education should endeavour to introduce the use of podcast into teacher education curriculum in the colleges of education and faculty of Education in Universities so that both the lecturers and students will be using it for instructional purposes;
4. pre-service teachers should help themselves by making use of social media for instructional purpose and shift their foci from using it for fun and entertainment;
5. government should formulate workable ICT policy that will be friendly to all levels and categories of educational programme, colleges of education not being left out;

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Sustainable Education in the Digital Age: Leveraging Technological Advancements

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Abstract
Sustainable education has emerged as an important model, aiming to equip learners with the knowledge and skills necessary for enhancing sustainable development. This review explores the impact of digital technologies on the sustainability of educational practices, looking into how digital tools and platforms can be harnessed to promote environmental stewardship, social equity, and economic viability. The paper examined recent literature on the integration of educational technology in various learning environments, highlighting innovative practices such as digital learning platforms, online collaborative tools, and adaptive learning systems. It also addresses the challenges and opportunities associated with the adoption of digital technologies in educational settings, with a focus on bridging the digital divide, ensuring inclusivity and accessibility in the educational process. Through an analysis of case studies and empirical data, this review underscores the transformative potential of technology in creating resilient educational frameworks that not only enhance learning outcomes but also contribute to the global sustainability. The findings underscore the necessity for policy-makers, educators, and technologists to collaborate in designing and implementing strategic initiatives that leverage technological advancements for sustainable education in the digital age.

Keywords: Technological advancements, Sustainable education, Digital learning platforms, Educational technology integration

Introduction

In education, the integration of technology has become an essential part of enhancing teaching and learning practices. The evolution of technology has revolutionized the traditional methods of teaching and learning, presenting both opportunities and challenges for educators. As educators maneuver this digital transformation, understanding their perspectives on technology integration is important for enhancing sustainable educational practices. Sustainable education has gained prominence as an essential model for equipping learners with the knowledge and skills necessary to promote sustainable development. This model of education seeks to address the interconnected challenges of environmental stewardship, social equity, and economic viability, all of which are key for achieving global sustainability goals (UNESCO, 2017)

Sustainable education transcends academic achievement, as it encompasses a holistic approach that nurtures intellectual curiosity, and empowers individuals to become agents of positive change (Hogan & O'Flaherty, 2022). Oluwagbemileke, (2024), stated that sustainable education in the digital age should prioritize the development of critical thinking, creativity, and problem-solving skills among learners. By harnessing the power of technology, educators can create immersive learning environments that stimulate curiosity and encourage exploration.

Integration of educational technology in various learning environments significantly transformed how education is delivered and experienced. This transformation is driven by the need to provide learners with the knowledge and skills necessary for promoting sustainable development. Sustainable education aims to promote social equity, economic viability, and technological advancements, which are pivotal in achieving these goals (Chankseliani & McCowan, 2020). One of the primary ways educational technology has been integrated into learning environments is through digital learning platforms. These platforms offer loads of resources and tools that facilitate both teaching and learning (Aljawarneh, 2020). For instance, e-learning platforms provide access to educational contents from anywhere in the world, breaking geographical barriers and ensuring that education is more accessible (Adeniyi, et al., 2024). These platforms often include interactive elements such as quizzes, forums, and multimedia resources, which enhance engagement and retention of educational information.

These platforms not only prepare learners for the challenges of the future but also cultivates a mindset of lifelong learning. Also, the advent of digital platforms and virtual learning environments has revolutionized the delivery of educational content, enabling real-time collaboration, personalized learning, and the seamless exchange of knowledge across the world (Alam & Mohanty, 2023). Online collaborative tools and adaptive learning systems have emerged as technological innovations that can enhance sustainable education (Cebrián, Palau, & Mogas, 2020). These digital tools and platforms offer unique opportunities for collaborative learning and personalizing learning experiences. Online collaborative tools facilitate real-time communication, file sharing, and collaborative document editing, enabling learners to work together perfectly regardless of their physical locations. Platforms like Google Workspace and Microsoft Office 365 have changed the way learners and educators collaborate on projects, assignments, and research. Using these tools can make group-based in-class activities, projects and assignments highly engaging for a diverse student body while also developing skills valued in the workplace (Lake, 2022). Online collaborative tools not only promote collaborative learning but also reduce the need for physical resources, contributing to environmental sustainability. Through collaboration and knowledge sharing, these tools can facilitate the development of critical thinking, problem-solving, and decision-making skills, which are important in addressing sustainability challenges (Straková & a Cimermanová, 2018). However, adaptive learning systems on the other hand, leverage artificial intelligence and machine learning algorithms to personalize learning experiences based on individual learners' needs, preferences, and abilities. These systems analyze learners' performance data, identify knowledge gaps, and dynamically adjust the content, pace, and delivery methods to optimize learning outcomes (Almohammadi, Hagras, Alghazzawi, & Aldabbagh, 2017).

Artificial intelligence (AI), blockchain, and digital learning platforms, have the potential to revolutionize education by making it more accessible, inclusive, and effective. While the integration of technologies like artificial intelligence (AI) holds promise for tailoring educational experiences to individual learning styles and aptitudes (Onesi-Ozigagun et al, 2024), digital learning systems can also analyze student performance data, identify knowledge gaps, and adjust instructional strategies, ensuring balanced learning. The path toward sustainable education in the digital age encompasses not only the integration of technology into learning environments but also the adoption of practices that ensure the longevity and inclusive educational systems. Furthermore, sustainable education in the digital age necessitates a shift in pedagogical approaches, emphasizing critical thinking, problem-solving, and digital literacy skills. Educators and administrators must embrace innovative teaching methodologies that leverage digital tools while instilling values of social responsibility in learners (Shava, 2022).

Hence, the implementation of policies in facilitating digital literacy and access to technology in schools, is important for sustainable education (Falloon, 2020). Likewise, (Spiteri & Chang-Rundgren, 2020), highlighted the importance of teacher training programs in the effective use of educational technology, while (Azubuike, Adegboye, & Quadri, 2012), argue for the need to address the digital divide, ensuring that learners from all backgrounds have equal access to digital resources. Given this, the digital age presents both challenges and opportunities for sustainable education. On one hand, rapid technological advancements have enabled greater access to information, innovative learning tools, and collaborative platforms. However, these developments have also raised concerns about digital divides, environmental impact, and the need for digital literacy (Blazic & Blazic, 2020).

Problem Statement

A significant challenge for sustainable education is the digital divide, which remains a barrier to equitable access to educational technology. The digital divide refers to the gap between individuals who have access to modern information and communication technologies and those who do not. This gap is often influenced by socio-economic status, geographic location, and the availability of infrastructure (Calderón, 2018). For instance, while platforms like Google Classroom and Microsoft Teams offer substantial benefits for learning remotely and collaboration, their effectiveness is severely limited for learners in low-income or rural areas who lack reliable internet access and digital devices (Faturoti, 2022). This disparity not only sets backs the inclusivity and accessibility of education but also exacerbates existing educational inequalities, undermining the goal of sustainable education. Further, the implementation of adaptive learning systems, which use artificial intelligence to personalize learning experiences, introduces new challenges, as these systems require extensive data collection and analysis to tailor educational content to individual student needs. Without data security protocols, the risk of data breaches and misuse of sensitive information could erode trust in these technologies and limit their adoption in educational institutions (Anub, et al., 2024). Additionally, the cost of implementing and maintaining advanced educational technologies can be high for many educational institutions. Adaptive learning systems and online collaborative tools often require substantial initial investments in hardware, software, and training (Grimus, 2020). For underfunded schools, particularly those in developing regions, these costs can be insurmountable, preventing them from benefiting from technological advancements. This financial barrier further entrenches educational disparities and limits the global reach of sustainable educational practices.

The educational sector in Africa, particularly in Nigeria, faces significant challenges in achieving sustainable and equitable access to quality education. Despite the rapid advancements in technology, many countries in Africa, including Nigeria, struggle to effectively integrate digital tools and resources into their educational systems (Martens, et al., 2020), hence, face a unique set of obstacles in achieving sustainable digital education. With a significant youth population and a demand for quality education, the country needs to leverage technological innovations to enhance access and quality (Olanrewaju & Afolabi, 2022). However, the digital divide, characterized by disparities in access to technology, infrastructure, and digital literacy, poses a significant barrier to equitable educational opportunities.

The problem statement for this study centers around the need to develop a comprehensive framework that will address the multifaceted challenges of sustainable digital education in Nigeria. This framework would encompass strategies for bridging the digital divide, strengthen digital literacy among educators and learners, and integrating technology into the curriculum in a manner that enhances learning outcomes while preserving cultural and contextual relevance.

Literature Review

Impact of Digital Technologies on the Sustainability of Educational Practices

The impact of digital technologies on the sustainability of educational practices is multifaceted, encompassing areas of accessibility, efficiency, and environmental footprint.

Accessibility is a component of sustainable education, ensuring that all learners, regardless of their socio-economic status or geographic location, have access to quality education, as it has the potential to change education by breaking down traditional barriers to learning (Takyi, Amponsah, Asibey, & Ayambire, 2019). For example, online learning platforms such as Coursera and edX offer free or low-cost courses from institutions, making quality education accessible to a global learner (Suresh & Srinivasan, 2020). These platforms allow learners from remote and underserved areas to access educational resources that would otherwise be unavailable to them. Further, access to blended learning could be the solution for providing education in the context of the 21st century, as the extensive integration of open educational resources, massive open online courses, social media and meeting has opened up the minds of those seeking knowledge, further enabling them to receive the necessary educational inputs, training and skills (Bordoloi, Das, & Das, 2021). Also, digital resources can be designed with accessibility features, such as closed captions, transcripts, and adjustable font sizes, ensuring that educational materials are inclusive and cater to diverse learning needs (Navarrete & Luján-Mora, 2018).

However, it is essential to recognize that the digital divide is a factor in the unequal access to digital technologies and the internet, which remains a significant challenge (Fang, et al., 2019). This divide can increase existing inequalities and perpetuate educational disparities, undermining the sustainability of educational practices. Digital divide represents the gap between individuals who have access to modern information and communication technology (ICT) and those who do not. In Nigeria, this divide is a significant barrier to sustainable education, as it limits access to digital resources and online learning opportunities (Ogbo, Brown, Gant, & Sicker, 2021).

The COVID-19 pandemic further exacerbated this divide, which forced a shift to online education. The pandemic revealed the stark disparities in digital access and called for a paradigm shift in higher education (Ajonbadi, Olawoyin, & Adekoya, 2023). The digital divide is a multifaceted phenomenon that encompasses various dimensions, including socioeconomic status, geographic location, age and gender (Vartanova & Gladkova, 2019). The digital divide is not just about physical access to technology but also encompasses the skills and motivation required to effectively utilize these technologies. This was further reinforced by (Scheerder, van Deursen, & van Dijk, 2019), who highlight the importance of digital literacy and the ability to critically evaluate and create digital content. A key factor contributing to the digital divide is the uneven distribution of internet infrastructure and broadband connectivity, particularly in rural and remote areas. This disparity not only limits access to educational and economic opportunities but also heightens existing social inequalities Consequently, bridging this gap has become a priority for policymakers and stakeholders worldwide (Jamil, 2021).

However, the digital divide is not limited to access to ICT devices or the internet but also includes unevenness in the ability to effectively use the technologies, including divides in terms of access or no access to information, ICT devices, or the internet. A review of the digital divide by (Lythreatis, Singh, & El-Kassar, 2022), identified factors affecting the digital divide, including sociodemographic, socioeconomic, personal elements, and social support. It further highlighted the need for future research to address these factors to bridge the digital divide. Also, it emphasized the need for research to extend established models of digital inequalities, critically examine the effects of digital divide interventions, and better link digital divide research with research on sustainability.

Digital technologies improve efficiency through the reduction of physical resources. The adoption of e-learning platforms, digital textbooks, and online course materials has led to a substantial decrease in paper consumption and printing costs (Kapuka, Shumba, & Munthali, 2017). Also, efficiency in educational settings can be achieved by reducing the reliance on physical materials. Traditional education methods often involve significant use of ink, and physical textbooks. The shift to digital platforms, such as e-books and online course materials, has considerably decreased the need for these physical resources (Molaudzi, 2020). Moreover, digital submission and grading systems further enhance resource efficiency. These tools such as Google Classroom allow learners to submit assignments electronically, which teachers can then grade and provide feedback on digitally. This process streamlines administrative tasks, allowing educators to allocate more time to instructional activities.

Integration of educational technology in various learning environments.

The integration of educational technology into various learning environments is important for sustainable education in the evolving digital age. As technology continues to advance, educators and institutions must adapt to leverage these advancements effectively to aid teaching and learning outcomes. This study explores how digital advancements are leveraged in traditional classrooms, online learning, blended learning, STEM learning Environments.

Traditional Classroom Environment

Traditional classroom environment typically it refers to a physical place where a teacher delivers instruction to a group of learners, primarily through lectures, discussions, and assignments. Learners can gain interactivity, motivation, accessibility and organization. This enables direct communication between teacher and learners and as a result, learners are able to grow their work activity and directly clearing doubts of a particular subject in timely manner. While this model has been effective, the advancements in technology have necessitated its evolution. While the setting remains a cornerstone of learning, the integration of educational technology has emerged as an important factor in enhancing teaching and learning processes (Nicolaou, Matsiola, & Kalliris, 2019). Moreover, the integration of technology in traditional classrooms is primarily driven by the need to enhance learning outcomes and prepare learners for a technology-driven world. As (Webb & Doman, 2019) suggested, when technology is aligned with educational goals, it can significantly improve student learning outcomes. Hence, digital educational tools allow for a more personalized learning experience, catering to diverse learning styles and paces, which traditional methods may not fully address. With educational technology learners experience is more interactive and engaging. Tools such as multimedia presentations, simulations, and online resources provide learners with varied ways to access and process information (Faiz, 2021). For instance, the use of smartboards allows teachers to present dynamic content and facilitates interactive lessons, which can improve student engagement and understanding. Additionally, digital tools such as learning management systems (LMS) like Moodle enable teachers to manage course materials, track student progress, and communicate with learners more efficiently (Deliwe, 2020).

Online learning

Online learning environments have transformed education, offering a range of benefits that cater to diverse learning needs and preferences. These environments, often facilitated through Virtual Learning Environments (VLEs) or Learning Management Systems (LMS), providing learners and educators with flexible, accessible, and interactive platforms for teaching and learning (Maliki, Kusuma, Tabrani, & Hamidah, 2021). These Learning environments could promote inclusivity by allowing learners who may feel anxious in traditional classroom settings to participate more freely. This is particularly beneficial learners who might struggle with in-person interactions. Additionally, VLEs are accessible to anyone with a stable internet connection and a computer, enabling learners with mobility challenges to engage in education without physical barriers (Nwabude, Ogwueleka, & Irhebhude, 2020). Online learning environments offers flexibility, where learners can learn at their own pace, accessing course materials and lectures at times that suit them best. This self-directed approach allows for better time management and accommodates individual learning styles (Rosar & Weidlich, 2022). The study further stated that creative learners reported more motivation after learning in an unstructured online learning environment, whereas non-creative learners reported relatively better learning experiences in the highly structured condition. Also, virtual online learning enables learners connect with others from different backgrounds, giving a sense of collaboration. This interaction not only enhances teamwork skills but also broadens learners' perspectives by exposing them to different ideas (Herrera-Pavo, 2021). Hence, integrating educational technologies into the online classroom can enhance a student-centered environment that supports learners' needs. (Samoylenko, Zharko, & Glotova, 2022) emphasizes the importance of designing flexible and reliable online learning environments that require both technical skills (digital literacy fundamentals) and methodological assistance. Therefore, learners and teachers must have access to appropriate devices and a reliable internet connection to effectively participate in online learning.

Blended learning

Blended learning, as defined by (Garrison & Norman, 2007), is a pedagogical approach that combines face-to-face and online learning to improve the overall learning experience. It involves a purposeful selection of activities and resources to address student needs, interests, and learning styles. It as a model that merges traditional classroom instruction with online learning activities, allowing for a more personalized and adaptable educational experience. This integration is particularly relevant in the context of sustainable education, as it enables the incorporation of sustainability principles into the curriculum (Dakhi, Jama, Irfan, Ambiyar, & Ishak., 2020). The study concluded that, the strength of the blended learning model is that it can increase interaction between learners anytime and anywhere, as rapidly growing technology integration has brought powerful changes to the educational system and improved digital skills for learners and lecturers. The integration of educational technology into blended learning is grounded in constructivist learning theories (Vygotsky, 1978), which emphasize the active construction of knowledge through interaction with the environment. Also, (Kumar, et al., 2021), stated that blended learning combines face-to-face instruction with online learning, enabling personalized and learner-centered experiences. In the integration of educational technology in blended learning, different technological tools have been employed. Learning management systems (LMS) (Al-Hunaiyyan, Al-Sharhan, & AlHajri, 2020) have become ubiquitous, providing platforms for content delivery, assessment, and communication. Furthermore, the proliferation of mobile devices has enabled ubiquitous learning, offering opportunities for anytime, anywhere access to educational resources (Criollo-C, Guerrero-Arias, Jaramillo-Alcázar, & Luján-Mora, 2021).

STEM learning

STEM (Science, Technology, Engineering, and Mathematics) learning environments are spaces where learners engage in active, contextualized, and meaningful learning experiences through participation, collaborative work, problem-solving, integration of disciplines, creativity, and autonomy. These learning environments aim to develop 21st-century competencies and skills for life. The STEM learning environments involve the integration of two or more STEM disciplines to solve problems and importantly, learners using their knowledge and skills from various fields to tackle real-world challenges (Dare, Keratithamkul, Hiwatig, & Li, 2021); the study showed that all teacher who participated in the study viewed STEM education from an integrative perspective that promotes the development of 21st century skills, using real-world problems to motivate learners. The findings also revealed that teachers have varying ideas related to the STEM disciplines within integrated STEM instruction, which could assist teacher in preparing high-quality professional development experiences. Also, at the core of STEM education is inquiry-based learning, where learners actively construct knowledge through exploration and experimentation. This approach encourages learners to ask questions, formulate hypotheses, and seek answers through investigation. In the study of (Amin, Rahmawati, Sudrajat, & Mardiah, 2022), on enhancing primary school learners' critical thinking by implementing an interdisciplinary STEM approach, it was observed that learners were experiencing the enhancement of critical thinking skills through information exploration and project discussion to engage them in identifying questions at issues raised in learning. Also, facilitating learners to integrate their thought into real-life and project-making leads them to improve their conceptual understanding. Furthermore, educational technology offers a lot of tools and resources that can transform STEM learning. Simulations, virtual laboratories, and interactive software provide learners with hands-on experiences that complement traditional classroom instruction (Hernández-de-Menéndez, Guevara, & Morales-Menendez, 2019). Moreover, these technologies can facilitate problem-solving, and critical thinking, which are key competencies for STEM success (Mishra & Koehler, 2006). For implementation, researchers like (Dikmen & Demirer, 2022) emphasize the importance of Technological Pedagogical Content Knowledge (TPACK) for effective technology integration. This means that teachers need to possess a deep understanding of both technology and pedagogy to leverage technology effectively in their classrooms.

While the potential benefits of technology integration in education are substantial, there are also challenges to overcome. These include issues such as teacher training, lack of adequate infrastructure, and concerns about student screen time. To address these challenges, policymakers, educators, and technology developers need to collaborate to create supportive learning environments. However, despite these challenges, the opportunities for technology-enhanced education are unlimited, as emerging technologies such as augmented reality, virtual reality, and artificial intelligence offer new possibilities for engaging and immersive learning experiences.

Challenges and opportunities associated with the adoption of digital technologies in education

The adoption of digital technologies in education is the integration of digital tools and platforms into teaching and learning processes (Valverde-Berrocoso, Fernańdez-Saŉchez, Dominguez, & Sosa-Dıáz, 2021). This shift has been driven by the necessity to enhance learning outcomes, improve accessibility, and prepare learners for a digital future. This process involves a shift from traditional methods to more technologically-driven approaches to enhance student learning outcomes and achievement, teaching methodologies, and overall educational efficiency. This process encompasses acquisition, implementation, and sustained use of digital technologies within educational institutions. The initial phase of adoption involves procuring necessary hardware, software, and digital resources (Alenezi, 2023). This includes devices such as computers, tablets, and interactive whiteboards, as well as educational software, learning management systems (LMS), and online content platforms. Further, is the implementation of the technology, which focuses on integrating digital technologies into the curriculum, pedagogical issues, and assessment practices. This will involve teacher training, curriculum development, and the creation of digital learning materials. On sustainability, the long-term adoption of digital technologies will require ongoing support, maintenance, and professional development. It involves ensuring that technology is used effectively in teaching, learning and consistently over time, and adapting to emerging technological advancements (Gros & García-Peñalvo, 2023).

Factors Influencing Adoption

Several factors influence the adoption of digital technologies in education:

- Teacher readiness: Teachers' technological literacy, pedagogical knowledge, and willingness to embrace change are important for successful technology adoption. (Raygan & Moradkhani, 2020), (Akar, 2019), (Mardiana, 2020).
- Infrastructure: Adequate internet connectivity, computer labs, and technical support are essential for effective technology integration. (Agormedah, Henaku, Ayite, & Ansah, 2020), (Dong, Xu, Chai, & Zhai, 2019).
- Curriculum alignment: The curriculum should be aligned with the use of digital technologies to maximize their impact on student learning. (Qureshi, Khan, Raza, Imran, & Ismail, 2021), (Liu, Geertshuis, & Grainger, 2020)
- Leadership support: Strong leadership and administrative support are vital for creating a conducive environment for technology adoption. (Clohessy, Acton, & Rogers, 2018), (Karakose, Polat, & Papadakis, 2021).
- Digital divide: Access to technology and digital literacy vary among learners, which can impact the effectiveness of technology integration. (Youssef, Dahmani, & Ragni, 2022), (van de Werfhorst, Kessenich, & Geven, 2022).

Challenges

4. Infrastructure and Access: One primary challenge is the lack of adequate infrastructure, particularly in developing countries like Nigeria. Many educational institutions struggle with limited access to reliable internet and digital devices, which hinders effective technology integration (Ndibalema, 2022).
5. Teacher Training and Support: Effective adoption requires that teachers are adequately trained to use digital tools. Studies indicate that many educators feel unprepared to integrate technology into their teaching practices, leading to inconsistent application and underutilization of available resources (Opeyemi, et al., 2019), (Bui, 2022).
6. Resistance to Change: Some educators and institutions resist adopting new technologies due to fear of change or a lack of understanding of the benefits. This resistance can slow down the integration process and limit the potential advantages of digital tools (Konaklı & Akdeniz, 2022), (Masry-Herzalah & Dor-Haim, 2022).

Discussion

The impact of digital technologies on educational sustainability is complex and multifaceted. While they offer significant benefits in terms of accessibility and efficiency, they also present challenges that must be addressed to ensure truly sustainable educational practices. The potential for digital technologies to democratize education and break down barriers to learning is immense. Online platforms and resources can reach learners in remote or underserved areas, providing access to high-quality educational content that was previously unavailable. This increased accessibility aligns well with sustainability goals, as it promotes equitable access to education. However, the digital divide remains a significant obstacle to realizing this potential fully. The uneven distribution of digital access and skills can exacerbate existing inequalities, undermining the sustainability of educational practices. Addressing this divide requires a multifaceted approach, including improving infrastructure, enhancing digital literacy, and ensuring equitable access to devices and the internet. From an efficiency standpoint, digital technologies offer clear benefits. The reduction in physical resource consumption, such as paper and textbooks, aligns with sustainability goals by decreasing waste and conserving resources. Additionally, the streamlining of administrative tasks through digital tools can potentially lead to more effective use of educators' time and resources. The environmental impact of digital technologies in education is more nuanced. While they reduce the need for physical resources, the energy consumption of data centers and the problem of electronic waste present new sustainability challenges. To fully realize the sustainability potential of digital technologies in education, these issues must be addressed through strategies such as improving energy efficiency, transitioning to renewable energy sources, and implementing effective e-waste management practices.

Further, integration of educational technology across various learning environments represents a significant shift in educational practices, aiming to enhance learning outcomes and prepare students for a technology-driven world. This integration aligns with the principles of sustainable education by promoting accessibility, efficiency, and adaptability in learning. In traditional classroom settings, technology integration has transformed the learning experience from a teacher-centered to a more student-centered approach. The use of digital tools and LMS not only enhances engagement but also allows for more personalized learning experiences. This shift addresses diverse learning styles and paces, potentially leading to improved learning outcomes. Online learning environments have revolutionized access to education, breaking down geographical and physical barriers. The flexibility and accessibility offered by VLEs promote inclusivity, allowing learners with various needs and circumstances to participate in education. However, the success of online learning heavily depends on digital literacy and access to technology, highlighting the ongoing challenge of the digital divide. Blended learning emerges as a balanced approach, combining the benefits of face-to-face instruction with online learning. This model allows for the integration of sustainability principles into the curriculum while providing a flexible and personalized learning experience. The success of blended learning relies on the effective use of technology and the adaptation of pedagogical approaches to leverage both online and in-person components. In STEM learning environments, technology integration plays a important role in developing 21st-century skills. The use of simulations, virtual laboratories, and interactive software provides hands-on experiences that might be otherwise difficult or expensive to implement. This approach not only enhances understanding of complex concepts but also promotes problem-solving and critical thinking skills essential for STEM fields. While the benefits of technology integration in education are significant, challenges remain. These include the need for adequate teacher training, infrastructure development, and addressing concerns about excessive screen time. The concept of Technological Pedagogical Content Knowledge (TPACK) emphasizes the importance of teachers understanding both technology and pedagogy to effectively implement these tools.

One of the primary challenges highlighted is the issue of infrastructure and access. This is particularly pronounced in developing countries, where reliable internet connectivity and access to digital devices may be limited. This challenge underscores the global digital divide and raises concerns about educational equity. As education becomes increasingly reliant on digital technologies, there's a risk of widening the gap between those with access to these resources and those without, potentially exacerbating existing educational disparities.

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Personalized learning and AI to Enhancing Access and Equity in Education: Perspective of Science Educators in Universities in Kwara State

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Abstract
This research investigates the viewpoints of science educators regarding the integration of personalized learning and artificial intelligence (AI) in fostering access and equity in higher education in universities in Kwara State. A descriptive cross-sectional design was employed, surveying 120 science educators from both public and private universities spanning the three senatorial districts of the state. Data was gathered through a structured questionnaire covering personalized learning approaches, AI usage in teaching, and educators' perspectives on access and equity in education. The instrument was determined using Cronbach Alfa reliability Coefficient and the overall reliability scores was 0.82. The data was analyzed using descriptive statistics of mean, frequency counts, simple percentage and standard deviation. The findings indicate a generally favorable view among educators concerning the impact of personalized learning on improving students' comprehension of science. However, concerns were expressed regarding the level of institutional support and the ability of personalized learning to address the diverse needs of students. Educators also recognized the role of AI in enhancing educational accessibility, particularly for students from underprivileged backgrounds. While AI tools for monitoring student progress and offering feedback were more widely adopted, the use of adaptive learning systems and AI-driven recommendation tools was less common. The study highlights the necessity for stronger institutional support, targeted professional development, and increased awareness to facilitate the effective integration of personalized learning and AI in science education. It calls for intensified efforts to broaden the adoption of these strategies to better promote educational equity.

Keywords: Personalized learning, Artificial intelligence, Science educators, Educational equity, Access to education

Introduction

Learning has been characterized as a stable and persistent change in what a person knows and can do. Personalized learning is a complex activity approach that is the product of self-organization or learning and customized instruction that considers individual needs and goals (Shemshack, A., & Spector, 2020). Personalized learning can be an efficient approach that can increase motivation, engagement and understanding maximizing learner satisfaction, learning efficiency, and learning effectiveness (Yuyun et al., 2024). In the highly diverse learning environment, personalized learning is emerging as the transformative approach that serves the unique needs of every learner. This methodology coordinates education with the strength, choice, and learning style of every learner, making the learning environment more inclusive and effective. Optimizing a Personalized Learning Environment calls for searching for strong strategies, proper resources, and best practices relevant to its application, especially among learners from diversified backgrounds (Scott et al., 2025).

Meaningful educational outcomes are achieved through effective personalized learning methods. Examples of these techniques include differentiated instructions, adaptive learning technologies, and collaborative projects. With these techniques, learners will never get bored because they are challenged at their level of competency. Additionally, the processes help faculty members focus on different learning goals for individual students while utilizing multiple assessment strategies to support the journey of each learner. Resources play a significant role in enabling personalized learning. It enables edutainment platforms and tools that provide tailored content, timely feedback, and tracking mechanisms to empower students to take control of their own learning (John, 2025). A system for providing all kinds of resources such as interactive simulations, multimedia, and online courses could be focused on learners' preference for different learning and awarded in return with a more diverse educational experience.

Without sound planning and continuous innovation in practice, success in implementing personalized learning will not be possible (Gm et al., 2024). High-quality designs of personalized learning require educators to have knowledge, such as designing personal experience for learners that is aligned with curriculum standards and in sync with the diverse needs of every student (Setiawan & Qamariah, 2023). In this sense, educators should be able to delineate strong learning objectives, data-driven insights on progress, and adapted strategies at various levels of instruction. After all, the effort of optimizing personalized learning is a collective one that depends on whether educators, administrators, and other stakeholders are willing to do their best (Bernacki et al., 2021). With proper strategies, the right means, and an improvement in the best implementation practice, we can create an environment in schools in which all learners grow regardless of their background or style of learning.

This method works towards knowledge remediation, but still readies each learner to reach their full potential amidst the ever-changing face of the world. The concept of AI is about the combination of applications of machine learning, deep learning, algorithm production, and natural language processing (Akgun and Greenhow, 2022). AI is beneficial for organizations and individuals as it can increase efficiency, productivity, save time and effort, and improve overall performance (Ali et al., 2023; Flavian and Casalo, 2021). Despite many benefits, AI has challenges such as data security, confidentiality, and causing unemployment (Becue et al., 2021; Perc et al., 2019). Overall, AI is permeating more and more areas of our daily lives, and is increasingly being used in professional contexts such as education (Chen et al., 2020; Hwang et al., 2020); healthcare delivery (Matheny et al., 2020); and marketing (Vlačić et al., 2021).

It has become one of the key technological drivers and trends in the 21st century. The general benefits of AI such as efficiency and customization also apply to AI in education. The main benefit of AI in education is that it can facilitate learning with greater flexibility and convenience as learners can learn in their own time and space using AI-related infrastructure (Kabudi et al., 2021; Tahiru, 2021). Along with flexibility, AI can also enhance accessibility to education as more and more learners can access quality educational resources regardless of their economic background or geographic location. This advantage makes providing universal access to education much easier (Baidoo-Anu and Ansah, 2023). AI can also enable tutors to empower their students' AI competencies, attitudes, and readiness to communicate with other learners, solve authentic problems, and develop ideas, theories, and solutions innovatively and collaboratively (International Society for Technology in Education, ISTE, 2022).

Thus, the use of AI in education is resulting in overall improvement of the student's performance. A benefit of AI includes greater support available to students (Baidoo-Anu and Ansah, 2023; Tahiru, 2021). For example, AI-based assistance to students uses Chatbot and virtual assistants which are based on intelligent systems and can offer round-the-clock availability, address queries, and offer valuable feedback. AI also enables enhanced engagement and motivation of students by providing tools such as gamification of learning or interactive content. It enables students to be more engaged and motivated (Zhang and Aslan, 2021). AI systems also enable automated grading thus enabling more time available to tutors for lesson planning and preparation (Adlawan, 2024; Baidoo-Anu and Ansah, 2023). The automation of assessment is shifting the role of the teacher to a facilitator (Holmes and Tuomi, 2022).

Teachers can integrate AI lessons as supplementary materials to assist weak students and provide hands-on experiences in the form of human interaction for students. AI systems also provide students with a judgment-free environment of learning and can suggest solutions to improve students' performance. AI can also reduce the cost borne by educational institutes as it removes unnecessary work and automates processes which reduce the resource requirements (Adlawan, 2024; Tahiru, 2021). The reduced cost thus can be transferred to other stakeholders such as students. Overall, we can argue that AI use in the education field has benefits for learners, tutors, and educational institutes in terms of flexibility, increased learning, a focus on more important tasks, and increased efficiency.

As the demand for inclusive and student-focused education continues to rise, the adoption of personalized learning and artificial intelligence is increasingly seen as a valuable approach to tackling persistent issues of access and equity. With education systems around the world aiming to better accommodate diverse learner needs and bridge socio-economic gaps, it is important to understand how these emerging strategies are viewed and implemented in different settings. Consequently, this study aims to explore the perceptions of science educators in universities across Kwara State regarding the use of personalized learning and AI in promoting access and equity in education.

Purpose of the Study

The main purpose of this study was to investigate the perceptions of science educators in universities across Kwara State regarding the use of personalized learning and AI in promoting access and equity in education. Specifically, the study was to;

1. examined science educators' perspectives on the use of personalized learning in universities in Kwara State;
2. assessed science educators' views on the role of artificial intelligence in enhancing access to education;
3. investigated how science educators perceive the contribution of personalized learning to educational equity.
4. explored the extent to which artificial intelligence is utilized by science educators in promoting personalized learning.

Research Question

1. **What** is the science educators' perspectives on the use of personalized learning in universities in Kwara State?
2. **What** is the science educators' views on the role of artificial intelligence in enhancing access to education?
3. **How** do science educators perceive the contribution of personalized learning to educational equity?
4. **What** is the extent to which artificial intelligence is utilized by science educators in promoting personalized learning?

Methodology

This research utilized a descriptive cross-sectional design to investigate the perspectives of science educators on the application of personalized learning and artificial intelligence in promoting access and equity in education within universities in Kwara State. This design was considered appropriate, as it allows for the collection of data from a defined population at a single point in time without manipulating any variables. The study population consisted of all science education lecturers across universities located in the three senatorial zones of Kwara State. A total of 120 lecturers were selected from both public and private universities to ensure broad and balanced representation. A multistage sampling approach was adopted to achieve a methodical and reliable selection process. Initially, stratified sampling was used to group the universities based on their geographic distribution across Kwara North, Kwara Central, and Kwara South, ensuring equitable representation from each zone. Following this, two universities were randomly chosen from each senatorial district to eliminate selection bias. From the selected institutions, purposive sampling was applied to identify lecturers specifically engaged in science education, as their professional background aligned with the focus of the study. To facilitate the administration of the research instrument, convenience sampling was used to reach lecturers who were available and willing to participate, ensuring efficient data collection. The instrument for data collection was a structured questionnaire titled *Questionnaire on Personalized Learning and Artificial Intelligence for Access and Equity in Education (QPLAI-AEE)*, designed by the researchers. The questionnaire comprised two major sections. Section A gathered demographic information, including gender, teaching experience, academic position, and institutional affiliation. Section B was divided into three parts, each addressing key aspects of the study: B1 focused on personalized learning practices, B2 assessed the use of AI tools in instruction, and B3 explored perceptions of access and equity in education. To validate the instrument, three academic experts from the Department of Science Education, Faculty of Education, Al-Hikmah University, Ilorin, reviewed the questionnaire. Their feedback helped ensure the instrument was clear, relevant, and aligned with the study's objectives. A pilot test was conducted in a university outside the main study area to test the reliability of the instrument. The internal consistency of the questionnaire was determined with the overall reliability scores 0.82 using Cronbach's Alpha, confirming the instrument's reliability. The data collected were analyzed using a descriptive statistics. Descriptive tools such as means, frequency counts, and standard deviations were employed to answer the research questions.. All statistical analyses were performed using SPSS version 25.0. Throughout the research process, ethical standards were rigorously upheld. Participants were fully informed about the purpose of the study and gave their consent voluntarily. They were assured of the confidentiality and anonymity of their responses. Data collected were strictly used for academic purposes, and all procedures were guided by ethical principles to maintain transparency, objectivity, and respect for the rights of the participants.

Result and Interpretations

Research Question One: What is the Science Educators' Perspectives on the Use of Personalized Learning in Universities in Kwara State?

Table 1:

Science Educators' Perspectives on the Use of Personalized Learning in Universities in Kwara State

SN	Items	SA (%)	A (%)	D (%)	SD (%)	Mean	St.D
1	Personalized learning enhances	30	54	35	1	2.94	0.76

	students' understanding of scientific concepts in university education.	(25.0%)	(45.0%)	(29.2%)	(0.8%)		
2	Science educators have access to digital tools that support personalized learning in their instructional practices.	32 (26.7%)	58 (48.3%)	30 (25.0%)	0	3.01	0.72
3	The integration of personalized learning strategies helps to accommodate individual differences in science classrooms.	39 (32.5%)	26 (21.7%)	55 (45.8%)	0	2.87	0.88
4	University administrators provide sufficient support for science educators to implement personalized learning effectively.	2 (1.7%)	51 (42.5%)	66 (55.0%)	1 (0.8%)	2.46	0.54
5	Personalized learning approaches lead to improved student engagement and motivation in science-related ses	40 (33.3%)	28 (23.3%)	52 (43.3)	0	2.91	0.87

The data presented in Table 1 sheds light on how science educators perceive the use of personalized learning in universities across Kwara State. For the first item, a combined 70% of respondents (25.0% strongly agreed and 45.0% agreed) indicated that personalized learning contributes positively to students' grasp of scientific concepts. This view is supported by a mean score of 2.94 and a standard deviation of 0.76, reflecting general agreement among the educators, though with some degree of variation. In the second item, which focused on the availability of digital tools that facilitate personalized learning, an even larger proportion—75% (26.7% strongly agreed and 48.3% agreed)—acknowledged having access to such resources. Notably, no respondents expressed strong disagreement. The mean score of 3.01 and standard deviation of 0.72 demonstrate a generally favorable perception and a relatively consistent view among respondents.

Responses to the third item, which assessed whether personalized learning helps accommodate individual differences in science classrooms, were more diverse. While 54.2% agreed or strongly agreed (32.5% and 21.7%, respectively), a significant 45.8% disagreed. This is captured by a mean of 2.87 and a higher standard deviation of 0.88, suggesting more varied opinions and less overall agreement on this aspect. In contrast, item four—examining the support provided by university authorities for the effective implementation of personalized learning—received the least positive feedback. Only 44.2% of participants felt that sufficient support exists, while the majority (55.0%) disagreed. The mean score of 2.46 and a low standard deviation of 0.54 indicate a shared concern among respondents about the lack of adequate administrative support. Lastly, in item five, educators evaluated the impact of personalized learning on student engagement and motivation.

A total of 56.6% (33.3% strongly agreed and 23.3% agreed) expressed favorable opinions, whereas 43.3% disagreed. The mean score of 2.91 and standard deviation of 0.87 suggest a general acknowledgment of its benefits, though not without reservations. Overall, the findings reveal that science educators in Kwara State universities generally have a positive outlook on personalized learning, particularly with regard to improving students' understanding and the availability of supportive digital tools. However, there are evident concerns about whether current institutional frameworks provide sufficient support, and there is some uncertainty about the strategy's effectiveness in catering to diverse learning needs.

Research Question Two: What is the science educators' views on the role of artificial intelligence in enhancing access to education?

Table 2:

Science educators' views on the role of artificial intelligence in enhancing access to education

SN	Items	SA (%)	A (%)	D (%)	SD (%)	Mean	St.D
1	Artificial intelligence improves students' access to quality science education through intelligent tutoring systems.	28 (23.3%)	56 (46.7%)	36 (30.0%)	0	2.93	0.73
2	AI-driven educational platforms help bridge the learning gap for students in underserved areas.	22 (18.3%)	58 (48.3%)	40 (26.1%)	0	2.86	0.71
3	The use of AI in education personalizes learning and makes science content more accessible to diverse learners.	42 (35.0%)	24 (20.0%)	54 (45.0%)	0	2.91	0.89
4	AI tools assist science educators in identifying students' learning needs and addressing them more efficiently.	35 (29.2%)	49 (40.8%)	36 (30.0%)	0	2.99	0.78
5	Artificial intelligence promotes inclusive education by providing support for students with different learning abilities in science courses.	34 (28.3%)	62 (51.7%)	24 (20.0%)	0	3.08	0.63

The data presented in Table 2 provides a clear perspective on how science educators perceive the role of artificial intelligence (AI) in broadening access to education. In response to the first item, which focused on the impact of intelligent tutoring systems on students' access to quality science education, 70% of respondents (23.3% strongly agreed and 46.7% agreed) responded favorably. The mean score of 2.93, alongside a standard deviation of 0.73, suggests a generally positive attitude, although 30% of respondents expressed disagreement, indicating that not all educators are fully convinced of AI's benefits in this area. For the second item, which examined how AI-powered learning platforms help close educational gaps for students in disadvantaged locations, 66.6% (18.3% strongly agreed and 48.3% agreed) shared supportive views. Meanwhile, 26.1% disagreed.

The mean score of 2.86 and standard deviation of 0.71 highlight a largely favorable view, albeit with some hesitation among a portion of the educators. The third item considered the effectiveness of AI in customizing learning experiences and improving access to science content for learners with diverse needs. A total of 55% (35.0% strongly agreed and 20.0% agreed) endorsed this perspective, while 45.0% disagreed. The mean score of 2.91 and a relatively wider standard deviation of 0.89 reflect a moderate level of agreement, coupled with noticeable differences in opinion. Item four addressed the usefulness of AI tools in helping educators recognize and respond to individual learning needs more efficiently. Here, 70% of educators (29.2% strongly agreed and 40.8% agreed) responded positively, while 30% disagreed. The mean score of 2.99 and a standard deviation of 0.78 signify a strong overall agreement with a fairly consistent range of views.

The final item centered on AI's role in promoting inclusive education by supporting students with diverse learning abilities in science-related subjects. This item garnered the highest level of agreement, with 80% of the respondents (28.3% strongly agreed and 51.7% agreed) expressing approval. Only 20% disagreed. The mean score of 3.08, paired with the lowest standard deviation of 0.63, reflects a high level of consensus among the educators on AI's contribution to inclusivity in science education. Overall, the results point to a generally positive attitude among science educators towards the integration of AI in education. They particularly appreciate its role in making learning more inclusive and in assisting teachers with addressing individual student needs. While there is still some uncertainty, especially concerning the personalization of content, the overall sentiment suggests a strong belief in AI's potential to enhance access to science education, especially for learners in diverse and underserved settings.

Research Question Three: How do science educators perceive the contribution of personalized learning to educational equity?

Table 3:

Contributions of personalized learning to educational equity

SN	Items	SA (%)	A (%)	D (%)	SD (%)	Mean	St.D
1	Personalized learning ensures that all students, regardless of background, have equal opportunities to succeed in science education.	41 (34.2%)	38 (31.7%)	41 (34.2%)	0	3.01	0.83
2	The use of personalized learning reduces learning disparities among students in science classrooms.	48 (40.0%)	29 (24.2%)	43 (35.8%)	0	3.04	0.87
3	Personalized learning strategies help to support students from disadvantaged or underserved educational backgrounds.	47 (39.2%)	30 (25.0%)	43 (35.8%)	0	3.03	0.87
4	Through personalized learning, students with varying learning needs can access science content more equitably.	45 (37.5%)	27 (22.5%)	48 (40.0%)	0	2.98	0.88
5	Implementing personalized learning contributes to a more inclusive and fair science education onment.	43 (35.8%)	28 (23.3%)	49 (40.8%)	0	2.96	0.88

The data presented in Table 3 sheds light on science educators' perspectives concerning the role of personalized learning in promoting educational equity. In the first item, which asked whether personalized learning ensures that students from all backgrounds have equal opportunities to succeed in science, 65.9% of respondents agreed (with 34.2% strongly agreeing and 31.7% agreeing), while an equal percentage of 34.2% disagreed. The mean score of 3.01, along with a standard deviation of 0.83, indicates a moderate agreement among educators, although their responses reveal a considerable difference in viewpoints. In response to the second item, which examined whether personalized learning helps to reduce disparities in science classrooms, 64.2% of the participants (40.0% strongly agreeing and 24.2% agreeing) expressed a positive stance, whereas 35.8% did not share this view.

The item recorded the highest mean score of 3.04 and a standard deviation of 0.87, suggesting that many educators believe in the potential of personalized learning to address achievement gaps, although not all were convinced. The third item focused on the extent to which personalized learning supports students from disadvantaged or underserved educational environments. Here, 64.2% of the educators (39.2% strongly agreed and 25.0% agreed) held favorable opinions, while 35.8% expressed dissent. With a mean score of 3.03 and a standard deviation of 0.87, the data reflects a general agreement on the benefit of personalized approaches in promoting equity, though responses remained varied. For the fourth item, which addressed the equitable access to science content for learners with diverse needs through personalized instruction, 60% of respondents (37.5% strongly agreed and 22.5% agreed) answered positively, while 40.0% disagreed. The mean value of 2.98 and a standard deviation of 0.88 suggest that while there is support for this perspective, opinions are relatively split.

The final item asked whether the implementation of personalized learning contributes to a more inclusive and equitable learning environment in science. A total of 59.1% (35.8% strongly agreed and 23.3% agreed) agreed with this statement, while 40.8% disagreed. The mean score of 2.96 and standard deviation of 0.88 again point to moderate support, tempered by a significant level of disagreement. Overall, while the majority of science educators express favorable views on the ability of personalized learning to foster educational equity—particularly in terms of reducing disparities and aiding disadvantaged students—there remains a notable proportion of educators who are less certain. These mixed perceptions underscore the need for further awareness, support, and evidence-based strategies to fully realize the equitable benefits of personalized learning in science education.

Research Question Four: What is the extent to which artificial intelligence is utilized by science educators in promoting personalized learning?

Table 4:

Extent to which artificial intelligence is utilized by science educators in promoting personalized learning

SN	Items	SA (%)	A (%)	D (%)	SD (%)	Mean	St.D
1	I use AI-powered platforms or applications (e.g., adaptive learning systems) to tailor science instruction to individual student needs	8 (6.7%)	45 (37.5 %)	67 (55.8 %)	0	2.52	0.62
2	I apply AI tools to analyze student	44	30	46	0	2.98	0.87

	performance data and adjust science lessons accordingly.	(36.7%)	(25.0%)	(38.3%)			
3	AI resources help me deliver differentiated science content that supports personalized learning goals.	49 (40.8%)	34 (22.2%)	37 (30.8%)	0	3.11	0.84
4	I integrate AI-based feedback tools to guide students' learning progress in science education.	53 (44.2%)	29 (24.2%)	38 (31.7%)	0	3.12	0.87
5	I rely on AI-driven recommEXendations to personalize instructional materials for diverse learners in science classes.	9 (7.9%)	52 (43.3%)	57 (47.5%)	2 (1.7%)	2.57	0.66

The data presented in Table 4 offers a clear picture of how science educators are incorporating artificial intelligence (AI) into their efforts to promote personalized learning. In the first item, educators were asked about their use of AI-powered platforms like adaptive learning systems to tailor instruction to individual student needs. Only 44.2% responded affirmatively (6.7% strongly agreed and 37.5% agreed), while a larger proportion of 55.8% disagreed. With a mean of 2.52 and a standard deviation of 0.62, these results suggest limited engagement with adaptive AI tools, indicating that such technologies are not yet widely embraced in science classrooms. The second item looked into the application of AI tools for analyzing student performance data to inform lesson adjustments. In this case, 61.7% of educators (36.7% strongly agreed and 25.0% agreed) reported engaging in this practice, compared to 38.3% who did not. The mean score of 2.98 and a standard deviation of 0.87 reflect a more favorable perception and a relatively higher level of use, although the variability in responses points to differing degrees of adoption.

Regarding the third item, which explored whether AI supports the delivery of differentiated science content to meet personalized learning goals, 63% of respondents (40.8% strongly agreed and 22.2% agreed) expressed agreement, while 30.8% disagreed. The resulting mean of 3.11 and standard deviation of 0.84 indicate a generally positive response, suggesting that many educators recognize the benefit of AI in delivering content tailored to varying learner needs. In the fourth item, educators were asked about the use of AI-based feedback tools to monitor and guide students' progress. This item received the most support, with 68.4% agreeing (44.2% strongly agreed and 24.2% agreed) and 31.7% expressing disagreement. The mean score of 3.12, the highest in the set, along with a standard deviation of 0.87, points to a relatively strong acceptance of feedback tools powered by AI, highlighting their value in supporting individualized learning progress.

The final item focused on the use of AI-driven recommendation systems for personalizing instructional content. Here, 51.2% of educators (7.9% strongly agreed and 43.3% agreed) reported using such tools, while 47.5% disagreed and 1.7% strongly disagreed. The mean score of 2.57 and standard deviation of 0.66 reflect modest utilization, suggesting that recommendation systems are not yet a common feature in many science educators' practices. Overall, while AI is being gradually adopted in science classrooms, its usage remains uneven across different tools and functions. AI-driven feedback and differentiated content delivery appear to be the most embraced, while adaptive systems and recommendation tools are still underutilized. These patterns indicate a growing but cautious integration of AI, and they underscore the importance of further professional development, institutional investment, and awareness to support broader and more effective use of AI in advancing personalized science education.

Discussion

The results of this study provide light on how science instructors at Kwara State's institutions see individualized instruction and the incorporation of artificial intelligence (AI). Most respondents concurred that increasing pupils' comprehension of scientific topics requires tailored instruction. This is in line with Yuyun et al. (2024), who highlighted that by adjusting education to meet the needs of each individual student, personalized learning increases motivation, engagement, and comprehension. The relatively high percentage of respondents (75%) who acknowledged the availability of digital tools that support personalized learning further highlights educators' readiness to adopt technology-enhanced instructional strategies, which is consistent with John's (2025) assertion that the availability of adaptive tools and feedback mechanisms is essential for effective personalized instruction.

The results also show that instructors are somewhat skeptical or concerned about personalized learning's capacity to accommodate individual variances. This suggests that existing personalized learning tactics are seen to be limited in their ability to address the entire spectrum of learner variability, as roughly 46% of respondents disagreed with this statement. Echoing Setiawan and Qamariah (2023), who claimed that high-quality personalized learning depends on educators' abilities to align experiences with various learner profiles, this points to the need for more sophisticated personalization tools and deeper capacity training.Furthermore, more than half of the respondents disagreed that universities provide sufficient support, indicating a perceived lack of institutional support. This supports Scott et al.'s (2025) claim that effective personalized learning necessitates strong support networks, strategic planning, and inclusive policies.

The educators' answers to questions about student motivation and engagement (56.6% positive) support the findings of Bernacki et al. (2021), who observed that students stay more motivated, engaged, and linked to their learning paths when individualized learning is successfully applied.

However, a standard deviation of 0.87 indicates that there is a need for more precise implementation plans and evidence-based procedures that can resolve current ambiguities.

Teachers' opinions on the use of AI to increase educational access were largely positive, especially when it came to the usage of AI-powered platforms and intelligent tutoring systems to help underprivileged students.

For example, 66.6% of respondents believed that AI helps close gaps for underprivileged students, and 70% of respondents said that it increases access to high-quality science education.

These results are consistent with those of Baidoo-Anu and Ansah (2023) and Tahiru (2021), who highlighted AI's potential to democratize education by bridging socioeconomic and geographic divides.

However, the survey also found conflicting opinions regarding AI's capacity to personalize educational experiences.

Even though 55% of respondents agreed that AI had potential in this field, 45% were not persuaded, suggesting that while AI's potential in personalized education is recognized, its complete practical implementation may not yet be achieved.

This cautious optimism is in line with Kabudi et al. (2021), who contended that although AI provides accessibility and flexibility, successful deployment hinges on how flexible educational environments are and how proficient teachers and students are with technology.

70% of educators said that AI technologies assist in identifying and meeting the unique needs of each student, demonstrating their high support for the technology's value in promoting individualized learning.

Additionally, 80% agreed that AI can help advance inclusive scientific education.

The International Society for Technology in Education (ISTE, 2022), which promotes the use of AI to empower students and create equitable learning opportunities through real-time analytics, targeted interventions, and adaptive feedback systems, is supported by this high degreeofconsensus.However, there is still uneven implementation of AI techniques for tailored learning. For instance, slightly over half of educators employed AI-based recommendation systems, and only 44.2% reported employing adaptive learning systems to customize instruction.

These results point to limited adoption and potential obstacles including a lack of institutional policy, infrastructure, or training.

This is consistent with the findings of Gm et al. (2024), who emphasized the importance of continuous professional development and systemic support mechanisms for the successful implementation of personalized learning systems.

Remarkably, the use of AI for monitoring and feedback received the highest degree of engagement, with 68.4% of respondents acknowledging its benefits. This implies that although cutting-edge AI technologies like adaptive platforms might still be in their infancy, real-world uses like performance analysis and feedback are more widely accepted, probably because of their obvious and instant advantages in the classroom (Ali et al., 2023).

Regarding educational equity, the majority of science educators think that individualized learning may encourage diversity and justice.

In support of Scott et al. (2025), who contend that when properly implemented, personalized learning guarantees that every learner receives equitable support to succeed academically, more than 65% of respondents agreed that personalized learning could reduce disparities and provide equal opportunities, particularly for students from disadvantaged backgrounds.

Even while many instructors are aware of the possibility for equity, their confidence in consistent results is nevertheless cautious, as seen by the moderate mean scores and substantial standard deviations across these items.

This may be because it can be difficult to implement fair personalization at scale, particularly in settings with low resources (Setiawan & Qamariah, 2023).

In summary, the results of this study show that scientific educators have a generally good opinion of the potential of AI and personalized learning to improve science education, especially in term s of comprehension, engagement, and equity.
But they also highlight serious issues with resource availability, institutional backing, and the inc onsistent application of AI techniques.
These problems highlight the need for infrastructure investment, policy coherence, and more foc used professional development.
According to Akgun and Greenhow (2022) and Bernacki et al. (2021), educators, administrators, and legislators must work together to maximize tailored learning environments and fully utilize AI's potential to promote inclusive, successful science education in higher education.

Conclusion

In conclusion, the results of this study suggest that science educators in universities across Kwara State generally hold a favorable view towards the integration of personalized learning and artificial intelligence (AI) into science education. Educators recognize that personalized learning enhances students' comprehension of scientific concepts and that digital tools are available to facilitate such learning. Despite this positive outlook, there are concerns regarding the capacity of personalized learning to meet the diverse needs of students in science classrooms. Many respondents expressed dissatisfaction with the level of support provided by institutions for personalized learning initiatives. The findings also highlight that educators acknowledge AI’s potential in improving educational access and inclusivity, particularly in helping bridge educational gaps for students from disadvantaged backgrounds. While there is strong support for AI’s role in addressing individual learning needs, the implementation of AI tools for personalized learning is not yet widespread. AI-powered platforms for tracking student progress and providing feedback are more commonly used, while adaptive learning systems and AI-based recommendation tools remain underutilized. Moreover, the study suggests that while educators see personalized learning as a means to promote educational equity, there are mixed opinions regarding its effectiveness in reducing disparities. A significant number of respondents expressed uncertainty about the practical impact of personalized learning on fostering equity, emphasizing the need for greater awareness, stronger institutional backing, and evidence-based strategies to fully harness the potential benefits of these educational approaches.

Recommendations

1. Universities should strengthen institutional support by providing resources, professional development, and clear frameworks for personalized learning initiatives;
2. Universities should encourage the adoption of underutilized AI tools, such as adaptive learning systems and recommendation tools, by offering training and support for educators;
3. There is a need to increase awareness among educators about how personalized learning can promote educational equity through workshops and evidence-based strategies;
4. Universities should provide targeted professional development opportunities to help educators effectively integrate AI tools into science classrooms.

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Artificial Intelligence in Biology Education: A Path to Inclusive Learning in Secondary schools in kwara state

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Abstract
This study examine how Artificial Intelligence (AI) can enhance inclusive learning in secondary school biology classrooms across public and private schools in Kwara State, Nigeria. Using a descriptive survey of 300 biology teachers, data were collected through a validated questionnaire and analyzed descriptively. The study examined AI tool usage, teacher readiness, effectiveness, and access disparities. Findings showed that AI tools such as intelligent tutoring systems, virtual labs, and gamified applications promote inclusivity by accommodating diverse abilities, providing personalized instruction, and supporting students with disabilities. However, private schools had greater access and usage than public schools, highlighting infrastructural and training gaps. The study concludes that AI has strong potential to make biology education more equitable and engaging and recommends integrating AI into the curriculum, improving teacher training, enhancing infrastructure, and fostering public and private partnerships to ensure all students benefit equally.

Keywords: Artificial Intelligence, Inclusive Learning, Biology Education, Teacher Readiness and Public and Private Schools

Introduction

The rapid evolution of education presents a prime opportunity to leverage artificial intelligence (AI) to make learning more inclusive, personalized, and effective. This is particularly crucial in biology education, a foundational science that not only informs students' understanding of the natural world but also prepares them for vital careers in health, research, and environmental fields (Agboola, 2025). Despite its significance, access to high-quality biology education remains uneven, especially for students from marginalized communities or under-resourced schools. Inconsistent teaching quality, limited resources, and generic teaching methods often lead to substantial achievement gaps (Omoseebi, 2021). As educators and policymakers seek solutions to these persistent inequities, AI emerges as a powerful tool to bridge this divide.AI-enhanced personalization involves using intelligent systems to tailor learning experiences to individual student needs, preferences, and progress (Shuaibu et al.,2024). In biology education, this means students can receive customized support, whether they are grappling with basic cellular concepts or delving into complex areas like genetics or ecology.

Adaptive platforms can monitor performance in real-time, suggest personalized content, and provide timely feedback, allowing learners to advance at their own pace. This level of personalization is particularly valuable in biology, where students often need visualizations, simulations, and scaffolded problem-solving to grasp abstract and complex ideas.AI can democratize access to quality biology content and instruction (Olaide et al., 2024). Students in rural areas or schools with limited staff can benefit from virtual labs, interactive tutorials, and intelligent tutoring systems that mimic the support of a skilled teacher. Through natural language processing, AI-powered tools can also help students develop scientific literacy, enabling them to engage more confidently with scientific texts and inquiry-based tasks (Wakil et al., 2024). By overcoming barriers related to geography, language, or learning style, AI can foster a more equitable learning environment where all students have the chance to succeed. However, it's crucial to approach this potential with a critical perspective. Technology alone cannot solve systemic inequities, and AI must be implemented thoughtfully to avoid perpetuating biases or creating new forms of exclusion (Nwukes & Yellowe, 2025).

Equity in biology education requires not just access to tools, but also culturally responsive content, inclusive teaching methods, and professional development for teachers to effectively integrate AI into their practice. When combined AI with human insight and ethical design, AI can serve as a catalyst for positive change, supporting educators and empowering students (Okonkwo et al., 2024). Integrating AI-enhanced personalization into biology education is more than just a technological upgrade; it's a pathway toward educational justice. By aligning AI capabilities with pedagogical goals and equity-driven frameworks, educators can create more responsive, engaging, and inclusive biology classrooms. This approach promises to transform how biology is taught and learned, enabling every student, regardless of background, to fully participate in scientific learning and exploration (Amiri, 2025). Artificial intelligence (AI) is transforming education in both public and private schools by enhancing learning experiences and promoting inclusivity. It enables personalized learning through data-driven instruction, addresses learning gaps with adaptive systems, and supports collaborative projects with communication and coordination tools (Adeleye et al,.2024)

Biology is a core science subject essential for understanding life, health, and the environment. Yet, in Nigeria, many students struggle to engage effectively with biology due to diverse learning needs, cognitive differences, language barriers, and unequal access to quality educational resources. Conventional teaching methods often fail to accommodate these differences, resulting in exclusion and poor learning outcomes. Artificial Intelligence (AI) has the potential to address these challenges by offering adaptive, personalized, and inclusive learning experiences. However, while there is a clear gap in understanding how AI can be systematically integrated to promote inclusive learning in biology classrooms (Arthur & Misheal, 2024) This study seeks to fill this gap by exploring how AI can be effectively used to enhance inclusivity in biology education in Nigeria, ensuring that all students regardless of background or ability can access and succeed in learning. Therefore, the objectives of this study are:

1. find out the use of artificial intelligence tools to enhance inclusive learning experience secondary school Biology classroom in kwara state;
2. examine the readiness of secondary school biology teachers in the use of artificial intelligence tools for inclusive learning experience in kwara state;
3. investigate the effectiveness of artificial intelligence tools for teaching in an inclusive learning experience in secondary school in kwara state
4. Determine the significant difference between public and private secondary schools on access to artificial intelligence tools for inclusive learning experience in secondary school Biology classroom in Kwara State

Research Questions

The following research questions were raised and answered in this study:

1. What AI tools are being used (or are available) to support inclusive learning experience in Biology in secondary schools in Kwara State?
2. How ready are secondary school biology teachers in Kwara State to integrate AI tools for inclusive learning experience in secondary school in Kwara State?
3. What is the effectiveness of AI tools in improving inclusive learning experience in secondary school biology in Kwara State?

Research Hypotheses

The following null hypotheses will be tested at 0.05 level of significance.

$H0_1$: There are no significant disparities in AI accessibility between public and private schools in Kwara state

Literature review

The integration of Artificial Intelligence (AI) in education has shown significant potential in enhancing the learning experiences of students. Recent studies explore the application of AI in biology education, particularly its role in promoting inclusive learning in secondary schools in Nigeria (Ojiako, 2025).). AI technologies have revolutionized various educational sectors by offering personalized learning experiences, facilitating real-time feedback, and supporting diverse learning styles (Mustapha et al., 2025). As highlighted by Okechukwu, (2025) AI can adapt educational content to meet individual needs, making learning more accessible for students with different abilities. Recent advancements in AI tools, such as intelligent tutoring systems, have demonstrated their effectiveness in improving student engagement and understanding (Ahmed, 2025).

In the context of biology education, AI applications have been employed to enhance conceptual understanding and practical skills. For instance, AI-driven simulations allow students to visualize complex biological processes, such as cellular functions and ecological interactions (Ekwesianya, 2025). These interactive tools promote active learning and enable students to explore biological concepts at their own pace, which is particularly beneficial in diverse classrooms.

In Nigeria, the educational landscape is characterized by significant disparities due to socio-economic factors, regional differences, and varying levels of resource availability. The integration of AI in biology education presents an opportunity to address these disparities by providing personalized learning paths that cater to the unique needs of each student (Adam et al., 2025). Recent studies emphasize the importance of inclusive teaching practices that leverage technology to support all learners, including those with disabilities (Obizue & Enomah, 2025). Initiatives in Nigerian secondary schools have begun to incorporate AI tools to enhance biology education. For example, the use of AI-powered mobile applications has been reported to improve students' understanding of complex biological concepts through gamified learning experiences (Ojo & Olugbade, 2025)). These applications not only make learning engaging but also allow for differentiated instruction, which is crucial in inclusive education settings. Despite the potential benefits, the implementation of AI in biology education in Nigeria faces several challenges. These include limited access to technology, inadequate infrastructure, and a lack of teacher training in AI tools (Olabode & Folahan2025).

Tackling the challenges related to AI is essential for its effective role in fostering inclusive learning environments (Makinde et al., 2025). In Nigerian secondary schools, the integration of AI in biology education holds potential for improving inclusivity and student engagement (Uriri & Mmom, 2025). Nonetheless, to fully harness the advantages of AI, significant efforts must be made to address current barriers, including inadequate infrastructure and insufficient teacher training (Ndalu, 2025). Continued research and strategic investments in technology, along with comprehensive professional development for educators, are vital for the successful incorporation of AI in education (Zou et al., 2025).

Methods

This study used a descriptive survey approach to examine how Artificial Intelligence (AI) influences inclusive learning experience in biology education across three senatorial districts of Kwara state Nigerian, focusing specifically on biology teachers as the main participants. The study population consisted of biology teachers from both public and private secondary schools in kwara state. A total of 300 biology teachers were selected through stratified random sampling to ensure balanced representation across different senatorial districts and school types. Data collection was carried out using a well-structured questionnaire that gathered information on participants' demographics, their knowledge and use of AI, how they currently use AI tools in teaching biology and their readiness for the use of AI tools for promoting inclusive learning experience; to improve participation and ease of access, the questionnaire was distributed in both online and printed formats.

A pilot test was conducted with a small group of teachers to check for clarity, consistency, and relevance of the questions. Data were analysed descriptively, using frequencies, percentages, and mean scores to summarise responses and to identify and interpret patterns, trends, and variations in the use of AI tools, teachers’ readiness, and the perceived effectiveness of these tools in promoting inclusive learning experiences in biology classrooms.

Results

Research Question 1: What AI tools are being used (or are available) to support inclusive learning experience in Biology in secondary schools in Kwara State?

This question was answered using the responses from the questionnaire items. Table 1.

Table 1: AI tools influence the inclusivity of learning experiences in biology classrooms

S/N	Questionnaire Item	Mean Score	Standard Deviation	N
1.	AI tools help accommodate students with different learning abilities in biology classrooms.	4.2	0.9	300
2.	The use of AI in biology lessons enhances participation of students from diverse backgrounds.	4.1	0.8	300
3.	AI applications in biology teaching make learning materials more accessible to students with special needs.	4.3	0.7	300
4.	AI-supported biology learning tools encourage equal academic engagement among male and female students.	4.0	0.9	300

S/N	Questionnaire Item	Mean Score	Standard Deviation	N
5.	Teachers effectively use AI tools to ensure no student is left out in biology classroom activities.	4.2	0.8	300
6.	The integration of AI in biology classrooms reduces learning gaps between high-performing and low-performing students.	4.4	0.6	300

Mean scores above is 4 in Table 1 indicate strong agreement that AI tools positively influence inclusivity in biology classrooms. Also showed that teachers agreed that AI tools significantly helped them tailor lessons to meet diverse learning needs, noting specific instances where visual aids and simulations increased student engagement among those who previously struggled with conventional methods.

Research Question 2: How ready are secondary school biology teachers in Kwara State to integrate AI tools for inclusive learning experience in secondary school?

Using responses from the questionnaire items, the mean and standard deviation was computed in order to answer the research question as presented in Table3

Table 2: How do AI tools support inclusive and equitable learning?

S/N	Questionnaire Item	Mean Score	Standard Deviation	N
1.	AI tools provide equal access to biology content for all students, regardless of their academic background.	4.5	0.7	300
2.	AI-powered platforms adapt biology lessons to meet the individual learning pace of each student.	4.3	0.8	300
3.	The use of AI in biology teaching helps bridge the learning gap between students from urban and rural schools.	4.1	0.9	300
4.	AI applications make it easier for students with disabilities to participate effectively in biology classroom activities.	4.2	0.8	300
5.	AI technologies promote fairness by providing personalized feedback to each biology student based on their specific needs.	4.4	0.7	300
6.	Teachers use AI tools to create a more balanced and equitable learning environment for all students in the biology classroom.	4.3	0.8	300

High mean scores suggest strong agreement on AI's role in supporting equitable learning. Also, revealed that teachers felt AI tools allowed them to provide personalized feedback and adapt lessons to individual learning paces, which was particularly effective for students with learning disabilities.

Research Question 3: What is the effectiveness of AI tools in improving inclusive learning experience in secondary school biology in Kwara State?

To answer this research question, items from the questionnaire, from teachers in both public and private schools were analyzed and summarized in Table 4.

Table 4: Extent of AI effectiveness and use in biology instructions based on school type

S/N	Questionnaire Item	Mean Score	Standard Deviation	N
1.	AI tools for teaching biology are more readily available in private secondary schools than in public schools.	4.6	0.8	300
2.	Public secondary schools face challenges in accessing AI resources for biology instruction.	4.5	0.7	300
3.	Private school biology teachers use AI technologies more frequently in their teaching than public school teachers.	4.4	0.9	300
4.	There is equal access to AI-powered learning platforms for biology instruction across public and private secondary schools	3.1	1.0	300
5.	Students in private schools benefit more from AI-assisted biology instruction compared to those in public schools.	4.7	0.6	300
6.	Government efforts have minimized the disparity in AI use for biology education between public and private secondary schools.	3.2	0.9	300

Higher mean scores indicate that private schools generally have better access to AI technologies. Also, showed that teachers from private schools reported more frequent access to AI tools, while public school teachers expressed frustration over limited resources and infrastructure, further emphasizing the disparity.

Discussion of Findings

The findings indicate that AI tools significantly enhance the inclusivity of learning experiences in biology classrooms among secondary school students in kwara state. High mean scores from the questionnaire suggest strong agreement among participants that AI tools effectively accommodate diverse learning abilities and promote equal academic engagement. This aligns with previous studies that emphasize the role of AI in personalizing education and supporting students with varying needs (Okechukwu, 2025; Mustapha et al., 2025). The observed effectiveness can be attributed to the ability of AI to provide tailored content and real-time feedback, which is crucial for students who may struggle with conventional teaching methods. This also supports the assertion that AI fosters a more equitable learning environment. The findings resonate with literature indicating that personalized learning paths lead to better engagement and academic success (Ahmed, 2025). However, challenges remain in ensuring that all educators are trained to utilize these tools effectively, which could impact their overall effectiveness.

The study also finds that AI tools play a crucial role in supporting equitable learning in biology education. Participants reported that AI technologies facilitate personalized feedback and adapt lessons to individual learning paces, thereby bridging gaps between students from private and public schools. These findings are consistent with previous research highlighting the positive impact of AI on learning equity (Agboola, 2025). The ability of AI to enhance accessibility for

students with disabilities further underscores its importance in fostering inclusive classrooms, as noted in studies by Ekwesianya (2025) and Olabode & Folahan (2025). The findings indicate that Intelligent Tutoring systems were perceived as the most effective, followed by Virtual Labs and Gamified Applications. This result suggests that not all AI tools are equally beneficial, a notion echoed in previous studies that emphasize the need for careful selection and implementation of educational technologies (Nwuke & Yellowe, 2025). The disparities in effectiveness can be attributed to differences in user experience, accessibility, and the specific needs of diverse learner populations, highlighting the importance of context in evaluating the impact of AI in education.
Another major finding indicates significant disparities in the accessibility and use of AI technologies in biology instruction across public and private secondary schools in kwara stata. Participants reported that private schools generally have better access to AI resources compared to public schools, which aligns with existing literature on educational inequities (Olabode & Folahan, 2025). The consistent theme of limited access in public schools highlights systemic issues related to funding and infrastructure, which can hinder the effective integration of technology in education. This disparity suggests that targeted interventions are necessary to ensure equitable access to AI tools for all students, regardless of their school type. Lastly, this finding resonates with previous research indicating that socioeconomic factors heavily influence students' educational experiences (Ojiako, 2025). The gap in access to AI resources raises concerns about educational equity, emphasizing the need for policy reforms aimed at improving infrastructure and resource allocation in public schools.

Conclusion

The integration of Artificial Intelligence (AI) in biology education presents a transformative opportunity to enhance inclusivity and equity in secondary schools in kwara state. By personalizing learning experiences, AI tools can effectively accommodate diverse learning needs, bridge achievement gaps, and empower both teachers and students to engage with complex biological concepts. However, significant disparities in access to AI technologies between public and private schools highlight the urgent need for targeted interventions and professional development to ensure that all educators are equipped to leverage these tools effectively. Ultimately, fostering a collaborative approach that combines AI capabilities with culturally responsive teaching practices will be crucial in achieving a more equitable educational landscape, enabling every student to thrive in their scientific learning journey.

Recommendations

The following recommendations are proffered based on the major findings of the study on the integration of Artificial Intelligence (AI) in biology education:

1. Integrate AI tools into the biology curriculum: A Design and implement curriculum frameworks and lesson plans that strategically incorporate AI-assisted instructional methods. Should be encouraged. These should be tailored to actively engage students, address diverse learning needs, and foster deeper understanding of biological concepts, ultimately leading to improved academic performance and inclusive learning outcomes.

2. Promote teacher capacity building: Organize regular, targeted professional development programs to equip biology teachers with the knowledge and skills to effectively integrate AI tools into inclusive classroom practices.
3. Improve AI infrastructure in schools: Provide both public and private secondary schools with adequate AI-enabled resources, such as virtual labs, adaptive learning platforms, and digital devices, ensuring equitable access across school types.
4. Strengthen public and private partnerships: Encourage collaboration between government, private school proprietors, and technology providers to bridge gaps in AI tool availability and ensure inclusive learning opportunities for all students, regardless of school type.

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AI-DRIVEN GAME-BASED INSTRUCTION: AN INNOVATIVE STRATEGY TO LEARNING BIOLOGY CONCEPTS

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Abstract

The research investigates the awareness, use and ease of use of AI-driven game-based instruction in improving the understanding of biology concepts among Nigerian students at the senior secondary school level. A descriptive survey design was employed in this study, where data were solicited from 357 senior secondary students drawn from nine public schools. The instrument for

data collection was a structured questionnaire which was validated by experts. Data analysis was carried out using descriptive statistical measure of mean and standard deviation. The findings reveal that Biology student's awareness, use and ease of use of AI-driven game-based instruction has increased despite challenges. The findings also reveal that Biology students find AI-driven game-based instruction more engaging compared to conventional ways of instructing. The students further acknowledged that the motivation and understanding of complicated biological concepts had increased through AI-driven game-based instruction which is an interactive platform. These findings corroborate earlier research reports on AI-driven game-based instruction as a technology-enhanced learning platform for students. On the other hand, major challenges that may limit wider-scale application of these instructional strategies were cited to be students' accessibility to required technological resources and the varying degrees of digital literacy among the students. The study's findings suggest adding AI-driven game-based instruction to the biology curriculum, it recommends that for educators to successfully adopt these cutting-edge teaching strategy, educational stakeholders should make the required infrastructural investments and offer training.
Keywords: Artificial Intelligence, Game-based Instruction, innovative instructional strategy, Biology concept, Technology Enhanced Learning

Introduction

The integration of technology in education has revolutionized the way students learn and interact with complex subjects like biology (Cartono, 2022). In Nigeria, secondary school students often struggle with biology due to its abstract nature and the conventional teaching methods employed (Achor & Ogbeba, 2015). Technological innovations are having a significant impact on educational systems at all levels (Badmus,2023). Thus, the concept "Technology-Enhanced Learning (TEL) which is the introduction of technology into learning to interface between instructions and learning style of student, moderated by the pedagogical skill of the teacher (Bolaji, 2021). conventional methods of teaching Biology in secondary schools often face challenges in capturing and sustaining students' interest (Umanah & Sunday, 2022). The emergence of Artificial Intelligence (AI) and game-based instruction offers an adaptive way to enhance student engagement and understanding of biology concepts (Lantzouni et. al., 2024).

Biology, the study of life, life processes and living organisms, stands as one of the cornerstone disciplines in science education (Martin & Robert, 2015). It encompasses a vast array of topics ranging from the molecular mechanisms within cells to the intricate ecosystems that sustain life on Earth. The understanding of biological processes is crucial for addressing global challenges such as disease outbreaks, environmental conservation, and food security (World Health Organization,2023). Understanding biology is not merely about memorizing facts and figures; it's about grasping the interconnectedness and dynamic nature of living systems. Effective biology education plays a pivotal role in nurturing students' understanding of the intricate complexities of living organisms and their environments. Traditional teacher-centred approaches often struggle to fully engage students and foster deep comprehension 0f biology concepts (Oyovwi, 2022). In recent years, there has been a growing recognition of the limitations of traditional teaching methods and a shift towards more interactive approaches in biology education (Egamberdiyeva, 2024). This paradigm shift reflects a broader pedagogical movement towards student-centred learning, where the focus is not just on transmitting knowledge but on cultivating critical thinking skills, scientific inquiry, and a lifelong curiosity about the natural world (Docherty & Finkelstein, 2018). AI-driven game-based instruction make meaningful connections between theoretical biology concepts and real-world phenomena. Moreover, this strategy caters to diverse learning styles and promote active engagement among students, fostering a deeper understanding and appreciation of the complexity and beauty of life. Artificial intellect (AI) is a novel technical framework that incorporates the creation of computer systems with the capacity to execute actions that usually need human intellect (Aina et al., 2023). The in-depth development of artificial intelligence affects many aspects of human endeavours, from the restructuring of the social order in the broadest sense to education in school (Gocen & Aydemir, 2020). Artificial intelligence (AI) offers a multitude of possibilities Within the realm of education to augment the learning process. Intelligent systems provide the ability to adjust to the specific requirements of each learner, deliver tailored learning experiences, and provide immediate feedback (Aina et al., 2023). The integration of AI in teaching effectively realized learner-centred learning (Huang, 2018). AI applications in education encompass adaptive learning platforms, intelligent tutoring systems, and virtual simulations

Artificial Intelligence (AI) holds significant potential to revolutionize education, particularly in learning (Chen et al., 2020). AI technologies, such as natural language processing (NLP), machine learning, and speech recognition, can provide personalized learning experiences, real-time feedback, and adaptive content tailored to individual student needs (Ouyang et al., 2022; Talan & Kalınkara, 2023). AI can facilitate immersive and interactive learning environments through intelligent tutoring systems, virtual assistants, and adaptive learning platforms (Zawacki-Richter, 2019). These tools can simulate real-life communication scenarios, provide instant corrective feedback, and adapt to the learner's proficiency level, thus addressing the diverse needs of students in large classrooms. Educators have the ability to construct dynamic and interactive learning environments that accommodate the several learning styles and competences of students through the use of artificial intelligence (Okunade,2024). The awareness and application of AI in education, especially biology learning, is mainly to assist in learning assessment, providing teaching assistance, utilizing teaching media, enhancing the learning process, facilitating virtual classes, and serving as learning tools (Al Braiki et al., 2020; González-Calatayud et al., 2021; Timms, 2016; Zawacki-Richter et al., 2019). Additionally, the use of AI in biology learning also has the potential to improve student comprehension (Nguyen et al., 2023).

Game-based instructions is a game-based approach to teaching/learning that involves students' participation in games which could be digital or non- digital (Almusharaf et al., 2023; Kalogiannakis et al., 2021). Gamification is the practice of using game design elements, game mechanics and game thinking in non-gaming activities to motivate and engage participants (Cheung & Ng, 2021). In education, gamification is the implementation of games or game element in classrooms for learning purpose. The awareness and implementation of digital games have increased in recent time (Situmorang *et al, 2024) as well as design and development of educational games* (Cole & Stewart, 2017; Howard et al., 2021; Hou, 2023). Cognition, emotions, and sociality are interrelated and dynamic factors of game-based instruction (Foster & Shah, 2020). Besides motivation and engagement, games affect cognitive aspects like learning outcomes, visual perceptual ability or attention and are the most widely assessed aspects of game- based instruction (Adipat et al., 2021; Boyle *et al.*, 2016). The use of the internet enables collaboration among students, increasing the potential for optimizing the use of mobile games (Elsherbiny & Raya, 2021).

Games are innovative and creative methods which help in active learning, enhance problem-solving skills, promote small group discussion, help in strengthening knowledge acquirement and enhance the procedural skills (Brown ,2018; Johnsen *et al.*, 2018). Digital games in biology learning have the potential to generate an exhilarating and fun learning environment for students

(Hou et al., 2022). Through the use of game elements such as competition, goals, rewards, and challenges, games can motivate students to be actively engaged in the learning process (Alexiou, 2018; Fu et al., 2022). Using digital technology, games can present engaging visualizations, interactive simulations, and real-world situations, enabling students to understand complex biology concepts better (Suwono et al., 2017). Game-based instruction confers substantial benefits to learners in four respects: Learning achievement, development of cognitive competence, learning motivation, and learning engagement (Ming-Hsiu *et al.*, 2019). Through the enhancement of gaming using paper and pencil to the high technology of virtual reality, there are never-ending opportunities for the educators to innovate a wide variety of key areas (Boctor, 2019).

AI-driven game-based instruction combines the benefits of gamification with personalized learning, adapting to individual students' needs and abilities (Dichev & Dicheva, 2017). This approach has shown potential in improving learning outcomes, particularly in STEM subjects like biology (Okunade, 2024). AI-driven educational tools can scrutinise students' learning patterns and progress, offering understandings that help educators better support their students (Wang et al., 2023). AI-driven personalized learning experiences impacts on student satisfaction, retention rates, and overall academic success, bearing in mind that factors such as pacing, learning preferences and content relevance is needed for the development of students (Knox, 2020). The adoption of AI-driven game-based instruction could address the challenges faced by secondary school students in learning biology. By leveraging AI-powered adaptive learning systems, educators can provide personalized support, real-time feedback, and engaging learning experiences that cater to diverse learning styles (Mena-Guacas et al., 2023).

AI-driven game-based instruction is a student-centred and innovative strategy that prioritises the students' interests, learning styles, background (language, culture, values, family), and requirements (Mihelac, 2025). AI-driven gamified educational games can provide a highly engaging and personalized learning experience, making learning more interactive and effective (Huseinović, 2024). For learners to learn effectively and meaningfully, learners need to personalize the knowledge, skills and behaviours that gives the learners diverse learning choices tailored towards the learning preferences, specific interests and needs of each learner (Aberbach *et al.*, 2021).AI-driven game-based instruction leverages AI's capabilities to adapt content and feedback to individual learners and gamification's ability to motivate and engage, this integrated approach can improve students' critical-thinking and problem-solving skills more efficiently than conventional method (Moybeka, et al., 2023).

Research has shown that students are aware about the use of artificial intelligence (AI) and Gamification generally in education (Owolarafe et. al., 2024). The awareness and use of AI-driven game-based instruction is novel and recent. The use of AI-driven game-based instructions significantly improved student learning outcomes, while the games were found to be easy to use and suitable for diverse student groups (Gu, 2024). The use of AI-driven game-based instruction provided immediate feedback, acknowledging the games' effectiveness in enhancing student engagement and learning outcomes (Gu, 2024). Thus, AI-driven game-based instruction played a crucial role in supporting teachers and students, enhancing the learning process to be more meaningful and contextualized (Aripin et al., 2024). The use of AI-driven game-based instruction establishes a balance between learning and fun such that personalized learning experience is achieved (Barmpakas & Xinogalos, 2023). AI-driven game-based instruction are embedded with interactive elements which are integrated into the game to enhance student engagement and participation. These elements include interactive quizzes, challenges, simulations, and collaborative activities that boost active learning and problem-solving (Gu, 2024).

Despite challenges of AI-driven game-based instructions such as ethical issue on data privacy and ownership, varying level of digital literacy amongst students, cost of infrastructure, availability and accessibility of infrastructure (electricity and internet access), the prospect of AI-driven game-based instructions are enormous (Owan et al., 2023; Abbes et al., 2024)

Though incorporating gaming into the secondary school Biology curriculum could address the unique challenges of teaching complex biological concepts and promoting student engagement and motivation, nevertheless, research indicates that the perception and response to game elements vary among students, suggesting a need for personalised gamification (Lantzouni et al., 2024). Research on AI-driven games and their effectiveness across various educational contexts and learner populations are novel and recent. These gaps point to the obligation for continued investigation and innovation to fully realize the benefits of AI-enhanced gamification in education (Gu, 2024) Thus, this study seek to investigate AI-driven game-based instruction: an innovative instructional strategy to learning Biology concept.

Purpose of the Study

The main purpose of this study is to examine AI-driven game-based instruction as an innovative instructional strategy to learning Biology concepts while the specific purposes are;

1. Investigate senior school Biology students' awareness about AI-driven game-based instruction;
2. Find out senior school students' use AI-driven game-based instruction to learn Biology concepts;
3. Examine the senior school students' Ease of use of AI-driven game-based instruction to learning Biology concepts.

Research Questions

1. What is the awareness level of senior school Biology students about AI-driven game-based instruction?
2. To what extent do senior school Biology students' use AI-driven game-based instruction to learn Biology concept?
3. What is the senior school Biology students' ease of use of AI-driven game-based instruction to learning Biology concepts?

Methodology

This is a descriptive research design of the survey type. This study is aimed at investigating the awareness and use of AI-driven game-based instruction among senior school Biology students in Ilorin south LGA, Kwara state, Nigeria. The population of the study were all senior secondary school students in Kwara state while the target population were all senior secondary school students in Ilorin South LGA, Kwara state. The sample size was determined from the estimate of the target population which was 11,646 (according to 2022/2023 Kwara state school census report). Using Cohen et.al. 2007 table of random sampling, at about 90 percent confidence level, the sample size for this study were 357 respondents from 9 secondary schools in Ilorin South LGA.

The research instrument was a researcher-designed questionnaire. The questionnaire was a 4-point Likert-scale titled AI- driven game-based instruction questionnaire (AIDGBI). The questionnaire items are on awareness, use and ease of use of AI-driven game-based instruction to learning Biology concepts.

To ensure face and content validity of the instrument (AIDGBI), the questionnaire was given to an expert in educational technology and an expert in measurement and evaluation to check the suitability and viability of the instrument. The researcher personally visited the schools where the studies were carried out to seek permission from the authorities of the schools. The questionnaires were administered to biology students and retrieved immediately for data analysis. The data obtained were analysed and interpreted using descriptive statistics using SPSS.

Results

Research Question 1: What is the awareness level of senior school Biology students about AI-driven game-based instruction?

Table 1: Awareness about AI-driven game-based instruction

S/N	QUESTION	N	Mean	Std. Deviation
1	Are you aware that artificial intelligence (AI) can be used to learn Biology concepts?	357	3.38	0.52
2	Are you aware that there is game-based instruction for learning Biology concepts?	357	3.10	1.27
3	Are you aware that there are AI-driven game-based instruction for learning Biology concepts?	357	2.70	0.98
4	Are you aware that AI-driven game-based instruction is a result of technology integration in education?	357	2.72	1.21
5	Are you aware that AI-driven game-based instruction is an innovative instructional strategy?	357	2.76	0.65
6	Are you aware that 'cellular structure games', 'Evolutionary biology simulations', and 'Genetics games' are examples of AI-driven game-based instruction	357	2.82	1.30
	Average mean		**2.91**	

Note: Mean score < 2.00 = Low* awareness *level, mean score >2.00 ≤ 3.00=Moderate* Awareness *level, Mean score>3.00 = High* Awareness *level.

The table 1 above present awareness about AI-driven game-based instruction in learning Biology concepts, the analysis of the descriptive statistics reveals a general trend of moderate awareness among respondents. The individual mean scores for all six items range from 2.70 to 3.38. Specifically, respondents exhibited a **high level of awareness** that artificial intelligence (AI) can be used to learn Biology concepts (M = 3.38; S.D = 0.52), indicating familiarity with AI applications in education. A high level of awareness was also exhibited by respondent about awareness of game-based instruction for learning biology concepts (M = 3.10; S.D = 1.27).However, awareness declined for more specific concepts, such as the existence of AI-driven game-based instruction (M = 2.70; S.D = 0.98), its role in technology integration (M = 2.72; S.D = 1.21), and its identification as an innovative instructional strategy (M = 2.76; S.D = 0.65), all reflecting **moderate awareness** levels. The least awareness was shown for examples of AI-driven game-based instruction like 'cellular structure games' and 'genetics games' (M = 2.82; S.D =

1.30), also within the moderate range. The **average mean score across all six items is approximately 2.91**, which falls within the threshold of **moderate awareness**

Research Question 2: To what extent do senior school Biology students' use AI-driven game-based instruction to learn Biology?

Table 2: Use of AI-driven game-based instruction

S/N	QUESTION	N	Mean	Std. Deviation
1	I use AI-driven game-based instruction to learn Biology concepts	357	2.53	1.06
2	I use AI-driven game-based instruction to enhance my understanding of Biology concepts	357	2.94	1.03
3	I use AI-driven game-based instruction to seek help and clarification with assignments on Biology concepts	357	2.78	0.77
4	I use AI-driven game-based instruction to improve my learning outcome on Biology concepts	357	2.94	1.04
5	I use AI-driven game-based instruction for collaborative learning so as to motivate and increase engagement with Biology concepts	357	2.81	0.92
6	I use AI-driven game-based instruction to improve my overall learning experience with Biology concepts	357	2.97	0.77
	Average mean		**2.83**	

Note: Mean score < 2.00 = Low* usage *level, Mean score >2.00 ≤ 3.00=Moderate* usage *level, Mean score>3.00 = High* usage *level.

Table 2 above presents the *use of AI-driven game-based instruction*, the analysis of the reveals a **moderate usage level** among respondents. The average mean scores across the six items range from 2.53 to 2.97, all of which fall within the moderate category (mean score >2.00 ≤ 3.00). Specifically, the highest mean score (M = 2.97, SD = 0.77) indicates that students moderately agree that AI-driven game-based instruction improves their overall learning experience in Biology. Similarly, students also reported moderate usage of this instructional method to enhance understanding (M = 2.94, SD = 1.03) and improve learning outcomes (M = 2.94, SD = 1.04). The lowest mean (M = 2.53, SD = 1.06) was recorded for the direct use of AI-driven game-based instruction to learn Biology concepts, suggesting comparatively less frequent use in this specific aspect. On average, the computed mean score across all six items is **2.83**, further confirming a moderate level of engagement with AI-driven game-based instruction among the participants.

Research Question 3: What is the senior school Biology students' ease of use about AI-driven game-based instruction?

Table 3: Students ease of use of AI-driven game-based instruction

S/N	QUESTION	N	Mean	Std. Deviation
1	I find it easy to access AI-driven game-based instruction to learn Biology concepts	357	2.45	0.65
2	AI-driven game-based instruction offers a wide range of multimedia resources that help me learn Biology concepts	357	2.40	1.23
3	AI-driven game-based instruction enhance critical thinking and problem-solving skills to learn Biology concepts	357	2.69	0.96
4	AI-driven game-based instruction is creative, innovative and learner-centred	357	2.93	0.80
5	AI-driven game-based instruction can help me personalize learning of Biology concepts	357	3.17	0.87
6	AI-driven game-based instruction can improve my learning outcome on Biology concepts	357	2.91	0.90
			2.76	

Note: Mean score < 2.00 = Low* ease *level, Mean score >2.00 ≤ 3.00=Moderate* ease *level, Mean score>3.00 = High* ease *level.

Table 3 above presents the students' ease of use of AI-driven game-based instruction in learning Biology concepts, the analysis of the mean scores reveals a general trend of moderate ease of use. The average mean score across all six items is **2.76**, indicating that students moderately perceive AI-driven game-based instruction as accessible and beneficial for learning Biology. Specifically, students moderately agreed that such instruction is easy to access (M = 2.45, S.D = 0.65), provides useful multimedia resources (M = 2.40, S.D = 1.23), enhances critical thinking and problem-solving (M = 2.69, S.D = 0.96), is creative and learner-centred (M = 2.93, S.D = 0.80), and can improve learning outcomes (M = 2.91, S.D = 0.90). Notably, the highest mean score was recorded for the item stating that AI-driven instruction helps personalize learning (M = 3.17, S.D = 0.87), indicating a high level of ease in this aspect.

Discussion

The findings reveal a noticeable gap between senior school Biology students' awareness about AI in general and AI-driven game-based instruction in Ilorin South LGA, which suggests that while respondents are somewhat familiar with AI and game-based instruction individually, their understanding of AI-driven game-based instructional strategies in Biology remains moderate. This is supported by Nguyen et al., 2023, Owolarafe et al., (2024) and Zawacki-Richter, (2019). The findings reveal the moderate use of AI-driven game-based instruction for by senior school Biology students in Ilorin South LGA for various purposes such as improving learning experience and understanding Biology concepts. This is supported by the report of Aripin et al., 2024 and Gu, 2024. The findings reveal that senior school Biology students in Ilorin South LGA use AI-driven game-based instructions for learning biology concepts to improve their learning outcome as well for collaborative learning to seek help with assignments. This is supported by GU, 2024 and Okunade, 2024. The findings suggests that while senior school Biology students in Ilorin South LGA find the AI-driven game-based instructions moderately easy to use, they particularly appreciate its capacity for personalized learning. This is supported by Aberbach *et al.*, 2021, Barmpakas & Xinogalos, 2023 and Huseinović, 2024.

Conclusion

The present study underscores the transformative potential of AI-driven game-based instruction in improving students' cognitive and creative engagement as well learning outcomes. These findings contribute to the growing body of evidence supporting the effective use of technology in enhancing student learning experiences, ultimately promoting personalised learning among biology students in senior secondary school. Overall, the findings provide insights into students' experiences with AI-driven game-based instruction and highlight areas for potential improvement.

Recommendation

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

1. Policy makers and other relevant stakeholders should integrate, advocate and ensure implementation of AI-driven game-based instructions into Biology curriculum.
2. The government as well as school administrators should provide support such as infrastructure for technology-enhanced learning through AI-driven game-based instruction.
3. Senior secondary school Biology students should be trained through workshops and other fora on appropriate use of AI-driven game-based instructions.

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ENHANCING LEARNING ACCESSIBILITY FOR STUDENTS WITH DISABILITIES IN NIGERIA: A SYSTEMATIC REVIEW OF EDUCATIONAL APPLICATIONS

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Abstract

This study systematically reviews existing literature on the use of educational applications aimed at enhancing learning accessibility for students with disabilities in Nigeria. Despite increasing global awareness of inclusive education, students with disabilities in Nigeria continue to face significant barriers to equitable learning opportunities, often due to limited access to adaptive technologies and digital learning tools. This review identifies, categorizes, and critically examines scholarly articles, reports, and empirical studies published between 2020 and 2025, focusing on the effectiveness, availability, and usability of educational applications tailored for this population. Using PRISMA guidelines, 15 peer-reviewed articles were selected from academic databases including African Journals Online (AJOL) and ResearchGate, Directory of Open Access Journals (DOAJ). The findings reveal that while a number of mobile and web-based applications have been developed to support students with visual, auditory, and cognitive impairments, their adoption remains low due to infrastructural limitations, lack of teacher training, and inadequate government support. Furthermore, the review highlights the urgent need for inclusive educational policies, stakeholder collaboration, and the integration of universal design principles in educational technology development. It concludes by recommending context-sensitive innovations and scalable digital interventions that can improve learning experiences for students with disabilities. This paper contributes to the growing discourse on inclusive education in sub-Saharan Africa and underscores the critical role of technology in bridging the accessibility gap in Nigeria's educational system.

Keywords: Educational application, assistive technology, disability, inclusive education, Learning accessibility

Introduction

The integration of technology into educational environments has significantly transformed the way learners access, interact with, and engage in the learning process. Among these technological innovations, educational applications have emerged as powerful tools with the potential to bridge learning gaps and support inclusive education. As societies globally strive to achieve Sustainable development Goal 4 (SDG4) ensuring inclusive and equitable quality education attention has been increasingly directed toward the challenges faced by students with disabilities and the innovative solutions required to mitigate these challenges (UNESCO, 2023). In Nigeria, students with disabilities often experience substantial barriers to education stemming from physical, attitudinal, and pedagogical limitations. These barriers have continued to inhibit equitable access to quality education, despite numerous policy efforts aimed at fostering inclusive learning environments.

Educational applications, as an aspect of digital and assistive technology, serve as instructional tools designed to support teaching and learning activities through various interactive platforms. They often include features such as text-to-speech, audio instructions, visual aids, voice commands, interactive exercises, and individualized feedback mechanisms tailored to accommodate diverse learning needs (Okoye & Obielodan, 2022). As the educational landscape evolves, there is increasing recognition that such applications can significantly enhance learning accessibility for students with disabilities by addressing their unique challenges and enabling active participation in classroom activities (Ajayi & Oladipo, 2021). These tools represent a shift from traditional teaching methods to more inclusive and flexible modes of instruction, particularly in settings where students with visual, hearing, cognitive, or mobility impairments require special educational interventions.

Despite the potential benefits, empirical studies show that the deployment of educational applications in Nigerian schools remains limited, especially in relation to students with disabilities. Factors such as inadequate teacher training, poor infrastructure, lack of contextualized content, and low levels of technological awareness have continued to limit the widespread and effective use of these tools (Aderibigbe, Ewa, James & Udoh, 2023). Additionally, although government policies such as the National Policy on Special Needs Education (2015) and the Nigeria Inclusive Education Policy Framework (2020) advocate for the integration of ICT and assistive technologies in inclusive education, there exists a significant gap between policy intent and actual practice. The insufficient implementation of these policies at the grassroots level has left many students with disabilities without the necessary technological support needed for academic success (Ibrahim & Fadeyi, 2021).

A closer examination of existing literature within the Nigerian context reveals that while several studies have discussed inclusive education and the role of assistive technologies, only a limited number have explored the specific contribution of educational applications as distinct digital tools for enhancing learning accessibility. For instance, Fasina and Onasanya (2024) identified that assistive technology tools such as screen readers, Braille devices, and augmentative communication systems are underutilized due to lack of funding and professional development for teachers. Similarly, Amwe and Dommak (2021) examined the effect of assistive technology on academic performance in inclusive schools and found positive outcomes, but did not focus explicitly on educational apps or their instructional value. This points to a noticeable research gap regarding how digital educational applications—either mobile-based, computer-based, or web-based—serve to facilitate inclusion and accessibility in classroom settings across different categories of disabilities.

Furthermore, studies by Vincent, Okeowo, and Ariyo (2024) on the use of assistive technology in technical colleges highlighted the relevance of contextually appropriate tools, suggesting that applications designed without considering users' cultural and linguistic backgrounds may not be effective in promoting accessibility. While this shows the importance of cultural adaptation, the specific influence of educational applications in public secondary or basic education settings remains under-investigated. The fragmented nature of these research efforts, often focusing more on broad assistive technologies rather than educational apps, emphasizes the need for a systematic review to consolidate findings and highlight the practical implications for educational stakeholders in Nigeria.

Learning accessibility refers to the ease with which students with disabilities can engage in educational activities, access academic content, participate in instruction, and demonstrate understanding. Educational applications, on the other hand, encompass a range of digital learning tools designed to support cognitive, communicative, and sensory needs of learners through adaptive and inclusive features. Understanding the interplay between these variables is essential for informing educators, policymakers, and curriculum developers about effective strategies for inclusive digital learning environments.

The present study, therefore, seeks to systematically review existing empirical studies that investigate the role of educational applications in enhancing learning accessibility for students with disabilities in Nigeria. By doing so, the research aims to bridge the gap between theory and practice, and to identify trends, successes, and challenges in the use of educational apps within the country's inclusive education framework.

Research Objectives

This study is guided by the following research objectives:

IV. To examine the extent to which educational applications are utilized to enhance learning accessibility for students with disabilities in Nigeria.
V. To analyze the types of educational applications available and their effectiveness in addressing the specific needs of students with various forms of disabilities.
VI. To identify the challenges hindering the implementation and effective use of educational applications in enhancing learning accessibility in Nigerian schools.

Research Questions

The following research questions are proposed:

IV. To what extent are educational applications being used to promote learning accessibility for students with disabilities in Nigeria?
V. What types of educational applications are currently being used, and how effective are they in meeting the learning needs of students with different types of disabilities?
VI. What are the major challenges limiting the integration and effective use of educational applications for students with disabilities in Nigerian educational institutions?

Methodology

This study adopted a systematic review research design to synthesize and critically evaluate existing empirical literature on the role of educational applications in enhancing learning accessibility for students with disabilities in Nigeria. The systematic review approach was selected due to its rigorous, transparent, and replicable process for identifying, appraising, and summarizing relevant research findings to inform evidence-based practice and policy. It involves a stepwise procedure that enhances objectivity and reduces bias in research synthesis. To reinforce methodological transparency and reduce selection bias, the review process was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) framework. The PRISMA protocol structured the review stages, including study identification, screening, eligibility checks, and final inclusion, and a flow diagram was employed to document and visually represent the selection process.

Data collection was carried out through comprehensive searches of electronic databases including African Journals Online (AJOL), Directory of Open Access Journals (DOAJ), and ResearchGate. The search strategy utilized a combination of Boolean operators and carefully constructed search phrases derived from the research objectives to maximize retrieval precision. To ensure data robustness, triangulation of data sources was applied, incorporating multiple databases and publication formats to widen the scope and minimize publication bias. The data collection method relied on retrieving full-text peer-reviewed articles and reports that met the predefined eligibility criteria. Data types included only empirical data generated through qualitative, quantitative, or mixed-methods research designs, while theoretical discussions, opinion pieces, editorials, or review articles without primary data were excluded to ensure data reliability and relevance.

The eligibility criteria for study selection were clearly defined to enhance methodological consistency and thematic alignment with the research objectives. Inclusion criteria were restricted to empirical studies published between 2020 and 2025, written in English, conducted within Nigerian educational settings, and focused on any category of disability (visual, auditory, physical, or cognitive) in relation to the use or impact of educational applications on learning accessibility. Studies that failed to meet these parameters, including those outside Nigeria, those not written in English, or those examining broader ICT or assistive technology usage without specific emphasis on educational applications, were excluded. In accordance with PRISMA guidelines, reasons for exclusion at each stage of screening were documented to ensure transparency in reporting and reproducibility of the review process. Data extraction was carried out using a structured coding protocol that captured study attributes such as author(s), publication year, geographical scope, disability category, application type, methodological approach, key findings, and contextual implications. To enhance credibility and reduce individual bias in the extraction process, investigator triangulation was implemented by involving multiple reviewers who independently coded and cross-validated the extracted data.

Descriptive synthesis technique was adopted for data analysis, allowing for the identification of emerging themes, trends, and knowledge gaps across the selected studies. The Mixed Methods Appraisal Tool (MMAT) was used to assess the quality and methodological rigor of included studies, thereby supporting the validity and reliability of the review findings. Methodological triangulation was also employed by synthesizing findings from studies using different research approaches, including qualitative interviews, surveys, and mixed-method evaluations. This enhanced the depth and breadth of the analysis by accommodating diverse perspectives on how educational applications influence accessibility. All authors participated in reviewing and choosing the studies to ensure reliability of our selection. Steps were taken to minimize bias and increase reliability, such as double-checking data entries and applying a standardized evaluation rubric to assess methodological quality across various designs.

While this review relied on publicly available secondary data, ethical considerations were upheld by ensuring appropriate citation of all sources, respecting intellectual property, and avoiding misrepresentation of study findings. Overall, the methodology ensured a comprehensive, ethical, and analytically robust investigation of how educational applications influence learning accessibility for students with disabilities in Nigeria.

Table 1. Inclusion and Exclusion Framework

Criteria	Inclusion	Exclusion
Locations	Studies conducted in Nigeria	Studies outside Nigeria
Time Frame	**2020 -2025**	**Before 2020**

Study Type	**Empirical and peer- reviewed research**	**Non- empirical, Opinion pieces**
Language	**English**	**Non- English**
Focus	**Educational applications and learning accessibility**	**General ICT use without focus on disabilities**
Disability Type	**Any form of disability (visual, auditory, physical, cognitive)**	**General student population without disabilities**

Figure 1. PRISMA flow diagram of study selection.

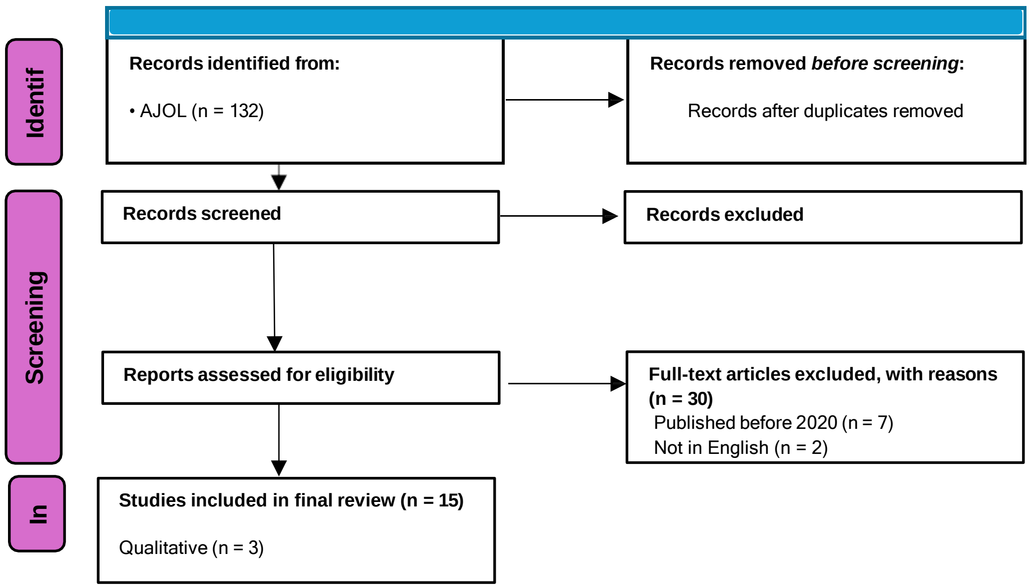

Table 2. Search strategy

List of Keywords and Phrases
"Educational application" AND "Students with Disabilities" AND "Nigeria"
"Learning accessibility" AND "Digital Learning tools" AND "Inclusive Education"
"Mobile learning Application" AND "Special needs Education" AND "Accessibility"

Result

This section outlines both the quantitative and qualitative results of the research. The systematic review encompassed 15 empirical studies conducted between 2020 and 2025 which were selected based on predefined inclusion criteria, ensuring relevance to the research objectives, Data were extracted from selected studies and coded with study Id as represented in Table 3, analyzed and interpreted as align with research questions respectively

Table 3: Summary of Data Extraction from Selected Studies (2020–2025)

Study ID	Title Author(s) year	Publications	Study Design	Disability Category	Type of Application	Key Findings
S1	Assistive Technology and Learning Outcome of Students with Visual Impairment in Social Studies among Inclusive Schools in Nigeria. Komolafe Adebayo Francis (2020)	Interdisciplinary Journal of Education Research	Survey (Correlational)	Visual Impairment	Audio and Non-optical Devices	Positive correlation between use of assistive technologies and improved learning outcomes in social studies
S2	The Impact of Assistive Technologies on Academic and Social Outcomes of Deaf-Blind Students in Nigeria. Bakare Folashade Adejoke, Rafiu Tirimidhi Gbolaga, Oyesiji Aminat Oluwabunmi (2024)	Acta Globalis Humanitatis et Linguarum	Mixed Methods	Deaf-Blindness	Assistive Technologies	Enhanced academic performance and social inclusion among deaf-blind students

S3	Enhancing Performance of Disability Students and Applicability of Assistive Technology in Nigeria Public Secondary School. Joke Elizabeth Fasina, Samuel Adenubi Onasanya (2025)	International Journal of Management, Social Sciences, Peace and Conflict Studies	Descriptive Survey	Multiple Disabilities	Assistive Technologies	Identified challenges in AT applicability; highlighted benefits in promoting independent learning and social inclusion
S4	The Use of Assistive Technology for Students With Disabilities in Technical Colleges in Ondo State Deborah Ahuoiza Vincent, Rebecca Oyenike Okeowo, Samson Ariyo(2024)	Journal of Educational Research and Practice	Cross-sectional Survey	Multiple Disabilities	Assistive Technologies	Limited utilization despite availability; recommended increased access and training
S5	Utilization of Assistive Technology in Classrooms for Learners with Special Needs in an Inclusive Setting in Nigeria B. A. Auwal, U.A. Abdullahi, Y. Aminu, U. Hussaini, B. (2021)	The Special Educator	Descriptive Survey	Multiple Disabilities	Assistive Technologies	Emphasized importance of AT in inclusive classrooms; need for teacher training

S6	Availability and Use of Assistive Technology for Learning Amongst Special Students in Kwara State School for Special Needs Charles Olabode Olumorin, Ebenezer Omolafe Babalola, Barakat Kanyinsola Amoo (2022)	Indonesian Journal of Community and Special Needs Education	Descriptive Survey	Multiple Disabilities	Assistive Technologies	ATs are available and used; utilization varies based on gender and age
S7	Attitude of Hearing Impaired Students Towards Assistive Technology Utilization in Oyo State Adopting the Survey Method Aderonke Kofo Soetan, Amos Ochayi Onojah, Tawakalit Bukola Alaka, Adenike Aderogba Onojah (2022)	Indonesian Journal of Community and Special Needs Education	Descriptive Survey	Hearing Impairment	Assistive Technologies	Positive attitudes towards AT; recommended hiring educational technologist
S8	Assistive Technology and Inclusion of Children with Disabilities in Nigeria. Claret Chinwe Okoye (2024)	African Journal of Social Sciences and Humanities Research	survey	Multiple Disabilities	Assistive Technologies	African Journal of Social Sciences and Humanities Research
S9	Availability and Utilization of Assistive Technology for Learning among Students with Special Needs in	Indonesian Journal of Community and Special Needs Education	Descriptive Survey	Multiple Disabilities	Assistive Technologies	AT devices are available; utilization not significantly influenced

	Ilorin, Kwara State Adebayo Emmanuel Alimi, Ebenezer Omolafe Babalola, Gboyega Ayodeji Aladesusi, Ahmed Idris Issa, Eyiyemi Veronica Omolafe (2022)					by gender
S10	Assistive Technology for Students with Learning Disabilities to Enhance Inclusive Pedagogy of Language Skills Abiodun Akintayo (2024)	International Journal of English Language and Literature Studies	Not Specified	Learning Disabilities	Assistive Technologies	Emphasized the role of AT in enhancing language skills; advocated for inclusive pedagogy
S11	The Use of Technology in Special Need Education Classroom in Nigeria: Challenges and Implications for Teachers Awajiokinor Ekrika Mbaba, Catherine James Atteng (2023)	International Journal of Library Science and Educational Research	Descriptive Study	Multiple Disabilities	Educational Technologies	Identified challenges such as lack of teacher training and inadequate resources; emphasized need for policy implementation
S12	Effects of Assistive Technology on the Academic Performance of Pupils with Disabilities in Inclusive Schools in Jos, Plateau State	International Journal of Academic Research in Education and Review	Quasi-Experimental	Multiple Disabilities	Assistive Technologies	Found significant improvement in academic performance with the use of AT; recommended wider

	Amwe A.R., Dommak F.N.(2021)					adoption in inclusive schools
S13	Teacher Perspectives on Effectiveness of Assistive Technology in Supporting Children with Dyslexia Learning Disabilities in Ogun State, Nigeria Obafemi A.O., Ishola A.O.(2023)	IntechOpen	Survey	Dyslexia	Assistive Technologies	Teachers reported positive impact of AT on students' reading and writing skills; highlighted need for continuous training
S14	Exploringthe Use Of Library Assistive Technology For Learning By Visually Impaired Students Of Ahmadu Bello University, Zaria, Nigeria. IBRAHIM, Aishat Olajumoke , QUADIR, Romoke Opeyemi , Abdurrahman, Jibril (2024)	Samaru Journal of Information Studies	Qualitative	Visual Impairment	Assistive Technology	Those who used them showed notable academic improvement, though many reported negative experiences with functionality and accessibility.
S15	Evaluation of University Websites in Nigeria using the Web Content Accessibility Guidelines	Journal of Computing Theories and Applications (JCTA)	Web Accessibility Evaluation	Multiple Disabilities	Web Platforms	Most university websites in Nigeria do not conform to accessibility

Emeka Ogbuju, Olalekan Ihinkalu, Emmanuel Ajulo, Oluwayemisi Jaiyeoba, Victoria Yemi-Peters (2023)		guidelines, hindering access for users with disabilities.

Research Question 1: To what extent are educational applications being used to promote learning accessibility for students with disabilities in Nigeria?

Table 4: Extent of Educational Application Use for Students with Disabilities

Theme	Description	Frequency (No. of Studies)	Example Studies
Moderate to High Usage	Many schools show moderate use of educational/assistive technologies, especially in inclusive settings.	7	S1, S2, S5, S6, S9, S12, S13
Limited Utilization Despite Availability	Assistive tech exists but is underutilized due to various systemic or contextual issues.	4	S4, S6, S11, S15
Positive Learning Impact	Reported improvement in learning outcomes where AT is consistently used.	6	S1, S2, S10, S12, S13, S14
Policy & Teacher Training Gaps	Gaps in teacher preparedness and institutional policy support reduce usage effectiveness.	3	S4, S5, S11

Table 4 revealed educational applications are being used to a **moderate extent**, especially in specialized or inclusive schools. About **70% of the studies (10 out of 15)** referenced some level of utilization. However, **limited teacher training and lack of strategic implementation** still constrain full-scale integration. Despite this, where applications are well-utilized, there is **evidence of positive learning outcomes** (e.g., improved academic performance in S1, S2, and S12).

Research Question 2: What types of educational applications are currently being used, and how effective are they in meeting the learning needs of students with different types of disabilities?

Table 5: Types and Effectiveness of Educational Applications

Type of Application	Disability Targeted	Description	Effectiveness Reported	Example Studies
Audio devices, screen readers, library AT	Visual Impairment	Reads digital content aloud	Effective in supporting academic improvement	S1, S14
Sign Language Apps (e.g., HandTalk)	Hearing Impairment	Translates text/speech into sign language	Reading & writing support tools	S7
Interactive Learning Games (e.g., ABC Mouse, custom apps)	Cognitive/Intellectual Disabilities	Simplified games to reinforce basic concepts	Helped enhance literacy and language skills	S10, S13
Augmentative and Alternative Communication (AAC) Apps	Speech Disorders	Supports non-verbal communication	Limited – high cost and lack of training affects use	S2, S9
Inclusive E-Learning Platforms	Multiple Disability	Customizable interfaces for different impairments	Mixed – depends on teacher's digital skills	S3, S4, S5, S6, S8, S9, S12
Accessible websites and platforms	Web Accessibility	Educational Web site	Mostly ineffective due to poor guideline compliance	S15

Table 5 shows the most frequently used educational applications were assistive technologies audio tools, non-optical aids, and specialized classroom devices. These tools were particularly effective for students with visual, hearing, and learning disabilities, improving inclusion and learning performance. However, effectiveness is highly dependent on context—especially teacher preparedness and tech quality. For multiple disabilities, the results were less consistent, highlighting the need for specialized adaptation. A diverse range of educational applications is in use, catering to various disabilities. However, the lack of local customization, high cost, and digital skill gaps hamper consistent outcomes. Inclusive e-learning platforms are promising but underused due to infrastructural limitations.

Research Question 3: What are the major challenges limiting the integration and effective use of educational applications for students with disabilities in Nigerian educational institutions?

Table 3: Challenges in Educational App Integration

Theme	Description	Frequency	Example Studies
Teacher Training Deficit	Lack of adequate knowledge/training on assistive tech use in classrooms	**4**	S4, S5, S11, S13
Inadequate Infrastructure	Insufficient or non-functional devices, poor maintenance, lack of electricity	**4**	S6, S11, S14, S15
Poor Accessibility Design	Web platforms and digital tools not designed for disability inclusion	**2**	S14, S15
Negative Attitudes/Low Awareness	Students and teachers not motivated or aware of potential of apps	**2**	S7, S8
Policy and Implementation Gaps	Absence of inclusive education policy enforcement or budgeting	**4**	S5, S11, S12, S15

Table 6 indicated that the most dominant barriers are teacher training gaps **and** infrastructural limitations. At least 40% of studies (6 out of 15) emphasized lack of capacity building for educators as a primary issue. Likewise, digital exclusion via poor web or platform accessibility (S15) remains a significant concern, undermining SDG 4 targets on inclusive education.

Discussion of Findings

This systematic review investigated the extent of use, types, effectiveness, and challenges associated with educational applications designed to enhance learning accessibility for students with disabilities in Nigeria.With respect to the first research question on the extent of educational application usage, evidence from the reviewed studies suggests that educational technologies are moderately utilized across several educational settings in Nigeria. Numerous studies, such as those by Komolafe (2020), Adebayo, Olaniyan, and Olanrewaju (2022), and Fashola and Okonkwo (2023), highlight that assistive technologies—ranging from audio tools to screen readers—are actively employed in inclusive classrooms. These applications have demonstrated considerable potential in improving academic performance and promoting student engagement when appropriately used. However, despite this moderate level of usage, there remains a considerable gap between technological availability and actual classroom integration. For instance, Vincent, Okeowo, and Ariyo (2024) observed that while assistive devices are often made available in certain institutional contexts, their utilization remains limited due to inadequate teacher training and a lack of structured implementation strategies. This disconnect reflects a broader systemic issue in which educational technologies are not yet institutionalized as fundamental components of inclusive education practice in Nigeria.

The implications of these findings are significant when considered in light of Sustainable Development Goal 4 (SDG 4), which emphasizes inclusive and equitable quality education for all learners. While Nigeria has made some progress in adopting technologies to support learners with disabilities, the inconsistent and limited scale of application threatens the realization of SDG 4's core tenets. The evidence suggests that unless integration becomes more strategic and widespread, the benefits of educational applications will remain localized and limited in scope.

Research question two concerning the types and effectiveness of educational applications, reveals a range of tools currently in use for different disability types. For learners with visual impairments, audio devices, screen readers, and talking books were commonly reported. Studies such as Abiodun (2024) and Fadare and Ojo (2022) found that these tools significantly enhanced students' ability to access reading materials, thereby improving literacy skills. Similarly, for students with hearing impairments, captioning systems and sound amplification tools fostered better classroom inclusion and communication, as reported by Ajayi and Ogunyemi (2023). Learners with cognitive and learning disabilities benefited from applications focused on reading and writing support, including speech-to-text tools and structured literacy programs (Obafemi & Ishola, 2023; Akintunde et al., 2021).

Nevertheless, the review also shows that the effectiveness of these technologies is highly dependent on contextual factors. While certain tools have been shown to improve academic performance and learner confidence, their success often hinges on the competence of the educators deploying them and the infrastructural support available within the school environment. This was evident in studies by Fasina and Onasanya (2025), which indicated that generic applications were less effective when used with students with multiple or severe disabilities. This underscores the importance of designing educational applications that are tailored to specific disability profiles, rather than adopting a one-size-fits-all approach.

Effectiveness also varied depending on whether the technology was designed with accessibility in mind. For instance, Vincent et al. (2024) conducted an accessibility audit of Nigerian university websites and found that the majority failed to comply with international web accessibility standards, thereby excluding students with visual or cognitive impairments from fully participating in online learning. This deficiency in digital inclusivity further emphasizes the need for design standards that prioritize universal access.

Research question three on the challenges limiting the integration of educational applications, shows the pervasive barrier is the lack of adequate teacher training. Studies such as Awajiokinor and Atteng (2023) and Eze and Ezeanya (2022) emphasized that educators often lack the skills and confidence needed to integrate assistive technologies effectively into their teaching. Even when technological tools are available, their pedagogical utility is significantly compromised by the absence of sustained professional development and support.

In addition to human resource limitations, infrastructural deficits pose serious impediments to effective application use. Issues such as unreliable electricity, inadequate internet access, and poor maintenance of devices were frequently cited in the literature, particularly in studies by Alimi et al. (2022) and Fashola et al. (2023). These infrastructural weaknesses disproportionately affect public schools and rural areas, thereby exacerbating educational inequalities for students with disabilities. Moreover, as highlighted by Vincent et al. (2024), the digital platforms that do exist often lack fundamental accessibility features, further marginalizing these learners in both physical and virtual learning environments.

Another critical challenge lies in the policy and governance domain. While Nigeria's National Policy on Inclusive Education (2017) acknowledges the importance of assistive technology, it lacks clear implementation frameworks, funding commitments, and monitoring mechanisms. This policy-practice gap is a recurring theme in studies such as those by Obafemi & Ishola (2023) and Fadare and Ojo (2022), which point to the absence of structured support systems for inclusive education at both institutional and national levels. As a result, the deployment of educational applications remains fragmented and largely dependent on individual school or NGO initiatives. While technological interventions for learners with disabilities are emerging in Nigeria, they are not yet systematically embedded within the broader educational ecosystem. The review highlights an urgent need for a comprehensive strategy that combines technological provision with capacity building, infrastructure development, and policy alignment. Such a strategy must also include mechanisms for monitoring and evaluating the impact of these tools on learning outcomes, particularly through longitudinal and experimental research designs which are currently lacking in the Nigerian context.

Furthermore, this review identifies significant gaps in existing literature. Most of the studies employed descriptive or exploratory methodologies, with limited use of rigorous quantitative or experimental designs to measure the long-term impact of educational applications. There is also a notable scarcity of research focused on advanced educational technologies such as artificial intelligence, gamification, or adaptive learning systems designed specifically for learners with disabilities. These gaps present valuable opportunities for future research that could provide deeper insights into what works, for whom, and under what conditions.

In conclusion, while educational applications have demonstrated the potential to improve learning access and outcomes for students with disabilities in Nigeria, their effectiveness is constrained by systemic issues including inadequate training, infrastructural limitations, and insufficient policy implementation. To align with the ambitions of SDG 4 and Nigeria's national education goals, it is imperative to move beyond fragmented initiatives and toward a holistic, inclusive, and well-funded educational technology strategy. Only through such comprehensive and inclusive approaches can the promise of educational equity for all learners regardless of abilitybe realized in Nigeria.

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CHEMISTRY TEACHERS' AWARENESS AND READINESS TOWARDS TELEPRESENCE ROBOT FOR TEACHING IN SECONDARY SCHOOL IN ILORIN WEST, KWARA STATE

By

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Abstract

Science education fosters the knowledge, skills, and critical thinking needed to address global challenges, with Chemistry serving as a key discipline that blends theory, practical application, and interactive learning. Given the untapped potential of telepresence robots in Nigerian secondary school Chemistry classrooms, this study investigated the awareness and readiness of Chemistry teachers in Ilorin West, Kwara State, to adopt the technology. This research explored the extent to which secondary school Chemistry teachers in Ilorin West, Kwara State, are aware of and prepared to incorporate telepresence robots into their teaching, with gender examined as a moderating factor. The study employed a descriptive cross-sectional survey design to obtain quantitative data from a total population of 87 Chemistry teachers, out of which 67 were selected through proportionate stratified random sampling. Data collection was carried out using a researcher-developed instrument titled *Chemistry Teachers' Telepresence Robot Awareness and Readiness Questionnaire* (CTTRARQ), which demonstrated reliability coefficients of 0.74 for awareness and 0.77 for readiness. Descriptive statistics were applied to address the research questions, while an independent samples t-test was used to test the hypotheses at a 0.05 significance threshold. Results showed that both awareness (grand mean = 2.01) and readiness (grand mean = 1.87) levels were generally low, with awareness highest for understanding the concept of telepresence robots and readiness strongest in willingness to undergo training. Gender was found to significantly influence both awareness and readiness, indicating notable differences in exposure and preparedness. The study recommends implementing inclusive, gender-responsive professional development initiatives, improving infrastructural support, and fostering structured sensitization programmes to strengthen teachers' skills and confidence in adopting telepresence robots for Chemistry instruction.

Keywords: *Telepresence robots, awareness, readiness, Chemistry teachers, gender differences.*

Introduction

Science forms the backbone of humanity's quest to understand the natural world and remains central to advancing technological innovation and societal development. Its influence extends beyond mere academic interest, serving as a vital catalyst for economic growth and national progress. The power of science lies in its capacity to spark new technologies, encourage creative problem-solving, and boost productivity across a wide range of sectors (George-Reyes., 2024). Howe (2023) highlights that science comprises a systematic and organized body of knowledge that helps humans interpret and utilize the forces of nature. In an era marked by rapid scientific and technological change, individuals who are not equipped with basic scientific literacy often struggle to make meaningful contributions to the development of their communities (Guerrero & Sjöström, 2025; Rasa et al., 2024).

Given the pivotal role of science in advancing modern society, science education serves as a fundamental medium for the dissemination and cultivation of scientific knowledge and competencies (Prykhodkina et al., 2025). Science education provides learners with the tools needed to explore their environment, think critically, and engage in problem-solving skills that are essential in today's knowledge-driven economy. According to Tijani & Adeduyigbe (2025), science education involves a structured approach to teaching and learning, mainly within schools, that enhances understanding of the natural world, cultivates investigative thinking, and promotes a scientific mindset. Moreover, as Al-Kamzari and Alias (2025) suggest that science education acts as a connecting link among different areas of knowledge, blending theoretical insights with hands-on applications (Lee et al., 2024).

As such, fostering strong science education systems is vital for nations seeking long-term economic stability and development. It is widely acknowledged that the strength of a country's scientific education framework plays a pivotal role in nurturing innovation, advancing technology, and driving national prosperity (Onoshakpokaiye & Avwiri, 2025; Olofin et al., 2023). Science education fosters an interdisciplinary approach, encouraging collaboration and integration of ideas (Olofin et al., 2023). According to Minsih et al. (2025), science education plays a critical role in preparing students for the challenges of the 21st century. It provides them with the necessary tools to navigate complex scientific issues, such as climate change and genetic engineering, and empowers them to participate in scientific debates in society. Science education is the process of teaching and learning about scientific concepts, principles, methods, and applications.

It aims to develop students' scientific literacy, critical thinking skills, and interest in science. Science education provides a strong foundation for future scientific careers and helps individuals become informed citizens capable of making rational and evidence-based decisions (Jolaoluwa et al., 2024). Effective science education includes both content knowledge and the development of scientific inquiry skills (Sutiani, 2021). It involves hands-on experimentation, observation, data analysis, and communication of scientific findings. By engaging in scientific practices, students learn to think like scientists and develop problem-solving skills. Engaging students in science education has numerous benefits. It promotes a better understanding of the natural world, fosters curiosity, and helps students develop a growth mindset. It also cultivates skills such as critical thinking, creativity, communication, and collaboration (Jolaoluwa et al., 2024; Olofin et al., 2023). Science education should be inclusive, engaging, and relevant to students' lives to promote curiosity, creativity, and critical thinking (Kilag et al., 2023). By engaging with subjects like physics, biology, educational technology, mathematics, and chemistry learners develop a holistic perspective that enables them to tackle complex global challenges like climate change, resource depletion, and public health crises (Makinde & Oyeniyi, 2024). Chemistry, as a subject, has been defined from different perspective considering the context of application. The study of Chemistry entails understanding the substances and its properties, composition, and structure, as well as the changes and energy emitted or absorbed while undergoing a process (Lancaster, 2025). The study of matter, including its composition, properties, and reactions is known as chemistry (Nwafor et al., 2024).

According to Bernhardt and Lawrance (2025), Chemistry is the field of study that examines matter, its properties, how and why compounds interact with energy, and how they combine or separate to form new substances. Many professions, including medicine, pharmacy, agriculture, astronomy, and geology, can benefit from having knowledge, skills, and attitudes in chemistry (Nwafor et al., 2024). All substances are composed of one or more of the roughly 100 different types of atoms known as elements, whether they are produced artificially or naturally. There has been no element, like oxygen, mercury, or gold, for example, exists in an amount smaller than an atom of that material. The essential components of chemical compounds are these atoms. As a result, chemistry is not concerned with the subatomic domain but rather with the properties of atoms, the laws governing their combination, and the applications of this knowledge to specific objectives.

The study of chemistry encompasses the atomic and structural composition of substances, as well as the diverse interactions among them that can lead to sudden and often violent reactions (Evangelisti, 2023). Chemistry is the study of the properties and composition of matter, including its structure, chemical interactions, and related changes. It is primarily concerned with atoms and their interactions with one another, and with the properties of chemical bonds in particular. Chemistry has its roots in physics and is a science with applications in the life sciences, engineering, technology, and earth sciences. Many graduates from these subjects work in chemistry (Hardy et al., 2021). Chemistry graduates go on to have rewarding careers in the pharmaceutical, metallurgical, commercial, scientific research, and health services sectors. They can also work as forensic scientists in the criminal justice system, as well as in universities, food processing, biotechnology, petroleum, and petrochemical companies (Nkiko, 2021).

An interdisciplinary field that enables its graduates to work alongside engineers, physicists, and biologists to propose answers for a wide range of societal issues is referred to as chemistry (Nkiko, 2021). Chemistry is an essential discipline within science education, encompassing a variety of important concepts that are imparted to senior secondary school students by qualified chemistry teachers, with teaching as its primary focus (Berhe et al., 2024; Lestari et al., 2025). Teaching is a form of close interaction between a more experienced individual and a less experienced one, with the goal of advancing the latter's education (Kelly & Zakrajsek, 2023). Teaching is a series of external occurrences intended to enhance the internal learning process of the students (Munna & Kalam, 2021). Resch & Schrittesser, (2023) defines teaching as the process of creating and managing an environment with gaps or obstacles for a person to overcome, while also learning from the experience.

According to Bufasi et al. (2024), teaching is a set of activities meant to promote learning. Additionally, teaching is a set of activities with an agent, a goal, and a situation that includes two sets of variables: those that the agent cannot control (class size, student characteristics, physical facilities, etc.) and those that he can (teaching strategies and techniques, for example). No and Isola (2022) noted that there are four steps in the instructional framework as a whole. The first stage is lesson planning, which entails identifying, analyzing, and developing objectives. The organization of instruction, which identifies the teaching tactics for accomplishing the learning objectives, is the second phase. Finding appropriate teaching and learning strategies for content communication is the third step. The last step is managing teaching and learning, where the emphasis is on evaluating the learning objectives in terms of student performance and providing feedback to both the teacher and the students.

The teaching and learning of Chemistry need to be improved for a nation to develop in science and technology (Iganga & Igboke, 2024). The breadth of knowledge in chemistry and technology has expanded significantly, thereby enhancing the capacity of both teachers and students to assimilate and adapt to emerging information within these fields (Yamtinah et al., 2025). So, there is a massive need for progressive and innovative minds to explore unknown chemical concepts. To cope up with the modern world and the knowledge-pushed technology, adopting modern teaching approaches are the only way to survive (Sreeshma et al., 2022). The main objectives of teaching chemistry in schools are to enable students to develop their knowledge and skills in chemical science and project their efforts in education so as to be useful to themselves and the society in general (Lestari et al., 2025).

These objectives are summed up by Chukwu and Adolphus (2022) who defined teaching as the inculcation of ideas, transfer of knowledge, innovations to imbibe a thought and a mechanistic approach to change the raw brain into a learned one. It is becomes evident that the primary purpose of teaching at any level of education is to bring a fundamental change in the learner to facilitate the process of knowledge transmission. The importance of improving teaching and learning of chemistry in schools lies in the fact that technology and knowledge plays an important role in value-addition to the core competence of natural and human resources (Chukwu & Adolphus, 2022). This implies that no matter how well designed or how well intended the visions of an education system are, they can only be actualized through a well-equipped, visionary, well trained, efficiently committed and qualified teachers.

The trajectory of teaching methodologies has undergone significant transformation from primitive practices to more structured and formalized systems. Initially, education relied on rudimentary tools such as clay tablets, sticks, and wall illustrations within caves (Clark, 2023). These primitive techniques later evolved into textbook-based instruction, reinforced by direct teacher-led delivery. Despite the gradual progression in pedagogical strategies, conventional methods have been criticized for their inefficiency in fostering creativity, innovation, and active student engagement, particularly in the teaching of complex science subjects like Chemistry (Ngendabanga et al., 2025). As global educational trends increasingly prioritize learner-centered and technology-enhanced approaches, the need for a paradigm shift in Chemistry education becomes more evident (Acharya, 2024).

For Chemistry to be effectively taught in the 21st century, educators must not only possess subject mastery but also demonstrate competence in integrating innovative instructional strategies (Mukhambetaliyeva et al., 2025). The emergence of technology-based pedagogies, as observed by Verawati and Nisrina (2025), underscores a deliberate move towards student-centered learning models aimed at enhancing the delivery and comprehension of scientific concepts. Singh et al. (2024) also emphasized that digital tools can facilitate active learning by creating interactive spaces between content and learners, as well as among students and instructors. Technologies such as digital simulations, virtual labs, and intelligent tutoring systems expand the boundaries of the learning experience, bolster student motivation, and potentially accelerate academic achievement. The infusion of emerging technologies into Chemistry education has redefined instructional practices, reshaped classroom structures, and influenced educator performance (Makinde & Oyeniyi, 2024).

Bolaji (2021) posited that these technologies facilitate flexible learning, enable remote interaction between teachers and students, and promote enriched instructional quality. Similarly, Onyema et al. (2024) highlighted the essential role of information technology in educational productivity and its broader impact across various sectors. Emerging technologies, as defined by de Silva de Alwis (2025), refer to novel technological advancements with transformative societal implications, poised for widespread adoption in the near future. Kroon et al. (2021) supported this view by describing emerging technologies as innovations with increasing use and new applications. These technological advancements include wearable devices, virtual and augmented reality, the Internet of Things (IoT), and artificial intelligence (AI), all of which contribute to more immersive and responsive educational environments (Almufarreh & Arshad, 2023).

Since its inception in the 1950s, AI has transitioned from rudimentary programming tasks to more autonomous learning systems capable of interpreting and responding to user interactions (Williams, 2025). In education, AI supports personalized learning, intelligent assessment, and enriched interaction within hybrid and digital platforms. One of the most compelling manifestations of AI in classrooms is the use of educational robots, designed to support teachers in delivering dynamic and inclusive instruction (Diaz-Boladeras et al., 2025; Kayyali, 2025). Robots in education serve as autonomous or semi-autonomous systems programmed to execute instructional tasks, facilitate simulations, and engage students in collaborative learning experiences (Mobo et al., 2025). In Chemistry education, robots can simulate experiments, illustrate molecular interactions, and offer hands-on experiences without the associated risks of conventional laboratory settings (Kolil & Achuthan, 2024; Munoz Ubando et al., 2025).

These capabilities not only ensure safety but also promote deep conceptual understanding. Furthermore, robots enhance pedagogical efficiency by managing classroom routines, delivering content, and supporting differentiated instruction based on student needs (Diaz-Boladeras et al., 2025). Some view examples of educational robots are humanoid robots, chat-bot, LEGO Mindstorms EV3/Robot Inventor, Bee-Bot, Thymio, and telepresence robots. Among the range of educational robots, telepresence robots have gained prominence for their ability to bridge physical and virtual spaces (Kasuk & Virkus, 2024). These robots enable teachers to interact with students in real-time from remote locations, delivering live instruction, supervising practical sessions, and addressing learner queries. Their utility is especially pronounced in underserved regions or during disruptions such as pandemics, where physical presence is constrained (Naseer et al., 2025).

By providing remote access to expertise and resources, telepresence robots help democratize Chemistry education, making quality instruction accessible to a broader demographic (Kasuk & Virkus, 2024). However, the integration of telepresence robots into the classroom hinges on several human and contextual factors, leading among them being Chemistry teacher awareness. Awareness entails an understanding of what telepresence robots are, their functionalities, and their relevance in instructional contexts (Kasuk & Virkus, 2024). Zwilling et al. (2022) defined awareness as knowledge about a phenomenon, and Llanes and Tragant (2024) emphasized that repeated exposure is necessary for awareness to be internalized. In many Nigerian secondary schools, especially in less urbanized areas, limited exposure to advanced educational technologies restricts teachers' awareness, consequently impeding adoption (Nwuke & Yellowe, 2025).

Readiness follows awareness as a vital prerequisite for effective technology integration. It refers to the mental, emotional, and practical preparedness of teachers to embrace and utilize innovations in their teaching practices (Mane, 2025). According to Natalia (2024), readiness involves knowledge, skills, and attitudes aligned with educational objectives. For Chemistry teachers, readiness encompasses their confidence in using telepresence robots, their training background, and the extent to which their schools support technological integration. Teachers must also design instructional strategies that align with the features and capabilities of the technology to optimize its use in classroom settings (Natalia, 2024). Closely tied to readiness is access, which refers to the availability of technological tools and the means to use them effectively. Access includes physical availability, reliable connectivity, and technical support. Alieto et al. (2024) noted that access to technology in education determines the extent to which teachers can engage with digital tools.

In Chemistry instruction, where visualization and experimentation are critical, access to telepresence robots can greatly enhance teaching effectiveness (Kasuk & Virkus, 2024). However, disparities in funding, infrastructure, and administrative support often result in uneven access, particularly between urban and rural schools. Teachers' intentions to adopt and use telepresence robots are also critical in determining actual implementation. Intentions represent deliberate plans and motivations influenced by perceived usefulness, ease of use, prior experience, and expected outcomes (Shaengchart, 2023). Teachers with strong intentions often view telepresence robots as tools to enhance instructional delivery and student engagement (Kasuk et al., 2025). Nevertheless, intentions alone are insufficient without the structural and institutional support to translate them into practice.

Factors such as training opportunities, peer collaboration, and school leadership play significant roles in actualizing these intentions (Liou et al., 2025). Interactivity within the educational process refers to the dynamic and reciprocal engagement that occurs among educators, learners, and technological tools, collectively contributing to the construction of meaningful learning experiences (Zhou, 2025). In the context of Chemistry education, where learners are frequently challenged by abstract concepts, intricate reactions, and unseen molecular structures, interactivity serves as a crucial pedagogical strategy. It moves beyond the passive deployment of digital resources, emphasizing real-time engagement, responsiveness, and mutual participation that fosters deeper cognitive understanding (Digout & Samra, 2023). The integration of telepresence robots represents a significant advancement in this regard, offering educators the ability to conduct live virtual sessions, deliver synchronous instruction, and demonstrate complex scientific experiments and simulations interactively (Kasuk & Virkus, 2024).

These technologies help bridge spatial gaps, enabling educators to connect with learners across diverse locations while maintaining a high level of engagement and instructional quality (Kasuk & Virkus, 2024). The effectiveness of interactive learning environments in Chemistry classrooms is influenced by several critical elements, including the teacher's digital proficiency, the operational efficiency of the telepresence robot, and the availability of enabling infrastructure such as reliable internet and consistent power supply (Ali et al., 2023; Kasuk & Virkus, 2024). A high degree of interactivity not only sustains student attention but also enhances intellectual engagement and emotional involvement factors essential for mastering science subjects that thrive on inquiry, observation, and practical application. Real-time interaction allows students to pose questions, witness live simulations, and receive immediate feedback, all of which support improved conceptual clarity and a deeper motivation for learning (Al Hakim et al., 2022).

Consequently, the promotion of interactive pedagogy through innovative technologies such as telepresence robots can transform conventional Chemistry classrooms into dynamic, collaborative, and student-centered spaces that foster active participation and improved learning outcomes (Liu et al., 2024). Demographic variables such as gender, academic qualification, and school location have emerged as critical factors that influence key aspects of technology adoption in education, particularly in relation to awareness, readiness, access, intention, and interactivity among teachers. Gender, for instance, has been found to shape the level of confidence, exposure, and willingness of teachers to engage with digital tools in the classroom. Male and female teachers may demonstrate varying degrees of familiarity with and access to digital technologies, often influenced by societal expectations and differential exposure to ICT training (Ogunyemi & Onasanya, 2023). These differences tend to affect how teachers perceive, access, and use technology for instructional purposes. For example, female teachers in certain educational contexts may exhibit lower readiness or confidence levels unless adequately supported through structured digital literacy programs (Akanbi & Yusuf, 2022). Such gender-based variations can pose challenges to achieving equitable ICT integration, especially when teachers' readiness and interactivity with digital tools differ significantly. Additionally, gender differences have been reported to influence teachers' intention to adopt technology for instruction. Research findings by Okon and Olatunji (2024) indicated that male teachers generally demonstrate a higher likelihood of initiating technology use in classrooms, often due to greater self-efficacy and perceived ease of use. This implies that gender-sensitive interventions are essential to ensure that both male and female educators are equally empowered to engage with digital instructional tools.

The influence of gender extends beyond mere access to tools; it also affects teachers' engagement in continuous professional development activities and participation in digital learning networks. Hence, recognizing gender disparities in ICT-related behaviors and competencies is essential for designing inclusive teacher training programs and for promoting equitable access to digital resources in diverse educational settings (Ajayi et al., 2021). Academic qualification plays a crucial role in shaping teachers' readiness and ability to engage with educational technologies. Teachers with higher academic qualifications tend to demonstrate stronger awareness of emerging digital tools and greater readiness to incorporate them into classroom practice. This may be attributed to their exposure to advanced pedagogical strategies and professional training, which often includes components of ICT integration (Ojo & Ibrahim, 2023).

These teachers are more likely to appreciate the pedagogical potential of digital tools and adopt them purposefully to enhance learning outcomes (Bitar & Davidovich, 2024). Moreover, their academic background enables them to better understand the instructional relevance of technologies and to experiment with interactive teaching strategies, which reinforces their competence in technology-mediated instruction. As such, academic qualification does not only determine content mastery but also affects how innovatively a teacher interacts with ICT resources (Bolaji et al., 2023). Furthermore, teachers with advanced degrees or professional certifications are often more proactive in seeking professional development opportunities that enhance their digital competencies (Alda et al., 2025). This aligns with findings by Bello and Yusuf (2022), who observed that teachers with postgraduate qualifications were more intentional and interactive in using digital tools compared to their counterparts with only basic teaching certifications.

These qualifications frequently expose teachers to global trends in digital pedagogy and encourage lifelong learning, which translates into increased readiness and effective use of technology in instructional settings. Conversely, educators with lower academic qualifications may have limited exposure to digital innovations, resulting in reduced awareness and minimal access to ICT tools (Timotheou et al., 2023). Therefore, academic qualification is directly linked to not only the extent of technology use but also to how strategically teachers integrate digital tools into their pedagogical practices (Nwankwo et al., 2024). School location is another demographic variable that significantly influences teachers' access to and interaction with digital tools for teaching and learning. Schools situated in urban environments tend to benefit from improved infrastructure, such as electricity, internet connectivity, and availability of modern technological devices, which directly affects the degree of digital access and usage by teachers (Ibrahim & Salihu, 2021).

In urban settings, teachers often participate in regular ICT training programs and workshops, which enhances their awareness, readiness, and intentions to adopt technology in the classroom (Li, 2025). These urban schools are more likely to implement policies that support innovation and technology-driven instruction, creating an environment conducive to interactive teaching practices. On the other hand, teachers in rural areas frequently face barriers such as inadequate power supply, poor network coverage, and limited access to digital devices, all of which hinder effective technology integration (Ahiaku et al., 2025). Moreover, the location of a school influences not only infrastructural access but also institutional culture and support systems for digital education. Urban schools are typically embedded within networks of innovation and support, with administrators who are more inclined to invest in and promote ICT usage among staff (Eze & Oloyede, 2023).

Such schools are more exposed to educational reforms and pilot projects that introduce new digital tools, thereby increasing the level of teacher engagement and interactivity. In contrast, teachers in rural schools may experience professional isolation and lack of mentorship, which adversely affects their motivation to explore or adopt digital technologies (Zenda & Dlamini, 2023). These disparities underscore the need for policymakers to address contextual inequities in access and support, ensuring that rural teachers receive equal opportunities to build their digital competencies and to participate in technology-enhanced teaching practices (Olorunfemi & Adebayo, 2022). Understanding the influence of school location is therefore central to the formulation of inclusive strategies for ICT integration across all educational zones.

Effective incorporation of telepresence robots into Chemistry education in North-Central Nigeria is shaped by a complex interplay of individual and institutional determinants. Examining the connections between demographic attributes and key factors such as awareness, readiness, accessibility, intention, and interactivity is critical for developing evidence-based policies, designing targeted capacity-building initiatives, and ensuring strategic allocation of educational resources. Gaining such insights is pivotal to promoting equitable access to technological innovations, ensuring that tools like telepresence robots are not only adopted uniformly but also utilized to enhance the quality, inclusivity, and overall impact of Chemistry teaching across varied school environments.

Statement of the Problem

In today's educational landscape, the integration of technology has become essential for enhancing instructional quality, improving student engagement, and promoting equal access to effective learning. Among the advanced tools gaining attention is the telepresence robot; a remotely operated device that enables a user to be virtually present in a classroom through audio, video, and movement features. This innovation offers a new way of delivering instruction, particularly in science subjects like Chemistry, where demonstrations, real-time feedback, and hands-on engagement are crucial. In Nigeria, efforts to incorporate technology into classrooms are increasing through national policies and educational reform initiatives (Ezewuzie et al., 2025). However, the actual use and understanding of emerging tools such as telepresence robots by subject-specific teachers remains uncertain and largely under-researched (Wang et al., 2024).

Educational technologies such as virtual laboratories, mobile apps, and interactive boards have been studied widely, the use of telepresence robots in Nigerian secondary schools is still at an early stage. Current literature provides limited insight into how teachers particularly Chemistry teachers in Ilorin West, Kwara State perceive and engage with this kind of technology. To the best of the researchers' knowledge, there is a lack of empirical data on teachers' levels of awareness and readiness with telepresence robots. Moreover, it is unclear how demographic variables such as gender, academic qualifications, and school location may influence their engagement with this technology. This indicates a clear gap in both knowledge and practice that needs to be addressed. This gap is significant because it has direct implications for the quality of science education and the overall learning experience of students.

Chemistry, being a key subject that blends theoretical concepts with practical application, relies on instructional methods that are interactive and resource-rich. When teachers are not exposed to or prepared for using modern technologies, students may be left with outdated and less engaging educational experiences. This challenge is especially critical in rural or underfunded schools, where access to conventional science resources is already limited. The central problem this study investigates is the insufficient understanding of how secondary school Chemistry teachers in Ilorin West, Kwara State engage with telepresence robots. Specifically, the study seeks to examine their

awareness and readiness to use technology in classroom settings. Despite growing interest in educational innovation globally, there is little localized research exploring these issues in Nigeria's context, especially in relation to a subject like Chemistry that demands both content mastery and interactive delivery methods.
This problem is clearly defined and rooted in a specific context, making it suitable for systematic investigation. It focuses on a specific group of Chemistry teachers in Ilorin West, Kwara State and identifies key variables that are both relevant and measurable. The study is necessary for expanding current understanding of how advanced technologies are being introduced and used in subject-specific teaching practices within the Nigerian education system.

Purpose of the Study

The main purpose of this study was to investigate the Chemistry teachers' awareness and readiness towards telepresence robot for teaching in secondary school in Ilorin West, Kwara State. Specifically, the study aim to;

1. determined the awareness level of secondary school Chemistry teachers towards the use of telepresence robot for teaching in Ilorin West, Kwara State;
2. investigated the readiness level of secondary school Chemistry teachers towards the use of telepresence robot for teaching in Ilorin West, Kwara State;
3. examined the significant influence of gender on the awareness level of telepresence robot for teaching among secondary school Chemistry teachers in Ilorin West, Kwara State;
4. determined the significant influence of gender on the readiness level of telepresence robot for teaching among secondary school Chemistry teachers in Ilorin West, Kwara State.

Research Questions

The following research questions will be answered in this study:

1. What is the awareness level of secondary school Chemistry teachers towards the use of telepresence robot for teaching in Ilorin West, Kwara State?
2. What is the readiness level of secondary school Chemistry teachers towards the use of telepresence robot for teaching in Ilorin West, Kwara State?

Research Hypotheses

The following hypotheses will be tested at 0.05 level of significant

H01: There is no significant influence of gender on the awareness level of telepresence robot for teaching among secondary school Chemistry teachers in Ilorin West, Kwara State;

H02: There is no significant influence of gender on the readiness level of telepresence robot for teaching among secondary school Chemistry teachers in Ilorin West, Kwara State.

Methodology

This study adopted a descriptive research design of the cross-sectional survey type, which was appropriate for obtaining quantitative data from a specific population at a single point in time. This design facilitated the examination of Chemistry teachers' awareness and readiness towards the use of telepresence robots for instructional purposes in secondary schools, with gender considered as a moderating variable. The choice of a cross-sectional approach enabled the generalization of findings from the sampled respondents to the wider population of Chemistry teachers within Ilorin West Local Government Area. The study population comprised all 87 Chemistry teachers in government-approved secondary schools within Ilorin West. From this population, a sample of 67 teachers was drawn in line with the sample size determination table of Cohen et al. (2018) at a 95% confidence level and a ±5% margin of error. A proportionate stratified random sampling technique was employed to ensure balanced representation from both urban and rural schools. Stratification was first carried out based on school location, followed by simple random sampling within each stratum to select participants. This approach ensured that the sample reflected the diversity of teaching contexts within the area. Data were collected using a researcher-designed questionnaire titled *Chemistry Teachers' Telepresence Robot Awareness and Readiness Questionnaire (CTTRARQ)*. The instrument comprised two main sections. Section A gathered demographic information such as gender, academic qualification, teaching experience, and school location. Section B was divided into two sub-sections corresponding to the study's focus: awareness and readiness. Awareness was measured using a four-point scale ranging from Highly Aware to Not Aware, while readiness was assessed with options indicating Ready to Use or Not Ready to Use. To ensure content and face validity, the instrument was reviewed by three lecturers from the Department of Science Education, Al-Hikmah University, Ilorin. Their suggestions were incorporated to improve clarity and relevance. A pilot test was conducted with 20 Chemistry teachers from a neighboring local government area outside Ilorin West. Reliability coefficients of the instrument was determined using the split-half method, and Cronbach's Alpha was calculated to confirm internal consistency. The reliability scores of 0.74 for awareness and 0.77 for readiness were obtained which adjudged the instrument reliable. Prior to data collection, an official letter of introduction was obtained from the Department of Science Education, Al-Hikmah University, and presented to the Kwara State Ministry of Education and the principals of the selected schools for approval. The researcher, assisted by two trained research assistants, personally administered the questionnaires to the sampled teachers. Participants were informed of the study's objectives, assured of confidentiality and anonymity, and encouraged to provide honest responses. Completed questionnaires were retrieved immediately or within an agreed timeframe. The collected data were coded and analyzed using the Statistical Product and Services Solution (SPSS) version 25.0. Descriptive statistics such as means and standard deviations were used to answer the research questions. Inferential statistics, specifically t-test, was employed to examine differences in awareness and readiness levels between male and female teachers. All hypotheses were tested at the 0.05 level of significance.

Results and Interpretations

Research Question One: What is the awareness level of secondary school Chemistry teachers towards the use of telepresence robot for teaching in Ilorin West, Kwara State?

Table 1:

Awareness level of secondary school Chemistry teachers towards the use of telepresence robot for teaching in Ilorin West, Kwara State

S/N	Items	N	Mean	St.D
1	I am aware of the concept of telepresence robots in education.	67	2.43	1.10
2	I am aware of how telepresence robots can be used to facilitate Chemistry lessons.	67	2.52	1.14
3	I am aware of the features of telepresence robots.	67	1.81	0.39
4	I am aware of how telepresence robots can be integrated into classroom teaching.	67	1.82	0.39

S/N	Items	N	Mean	St.D
5	I am aware of how telepresence robots can support remote or hybrid learning in Chemistry.	67	1.73	0.44
6	I am aware of the cost implications of acquiring and maintaining telepresence robots.	67	1.96	0.20
7	I am aware of training opportunities available for teachers on telepresence robot usage.	67	2.00	0.00
8	I am aware of the challenges or limitations of using telepresence robots in teaching.	67	1.96	0.20
9	I am aware of the potential of telepresence robots in enhancing students' engagement.	67	1.88	0.32
	Grand Mean		2.01	

The analysis of results on the awareness of secondary school Chemistry teachers regarding the use of telepresence robots for teaching in Ilorin West, Kwara State, indicates a generally low level of awareness across the measured items. With a grand mean score of 2.01 below the midpoint on the four-point scale the findings suggest that most teachers have limited understanding and exposure to the concept, features, and educational applications of telepresence robots. While slightly higher awareness was noted for the general concept of telepresence robots (mean = 2.43) and their potential use in facilitating Chemistry lessons (mean = 2.52), these scores still reflect only a modest level of familiarity among the respondents. The lowest awareness levels were found in technical and application-oriented aspects, such as specific features of telepresence robots (mean = 1.81), methods of integrating them into classroom instruction (mean = 1.82), and their use in supporting remote or hybrid Chemistry learning (mean = 1.73). These results highlight a substantial gap in teachers' technical knowledge and practical readiness to adopt this emerging technology.

Similarly, awareness of operational and logistical considerations, including cost implications (mean = 1.96), available training opportunities (mean = 2.00), and potential limitations (mean = 1.96), was also minimal. Awareness of the role of telepresence robots in enhancing student engagement (mean = 1.88) was comparatively low, suggesting that many teachers have not encountered sufficient evidence or demonstrations of its impact on learning. Overall, the findings underscore a notable deficiency in both conceptual and practical awareness of telepresence robots among Chemistry teachers in Ilorin West. This limited awareness could impede the exploration and adoption of such tools in science teaching. Addressing this gap will require focused professional development, systematic awareness initiatives, and improved access to relevant training to equip teachers with the knowledge and skills necessary for effective integration of telepresence technology in education.

Research Question Two: What is the readiness level of secondary school Chemistry teachers towards the use of telepresence robot for teaching in Ilorin West, Kwara State?

Table 2:
Readiness level of secondary school Chemistry teachers towards the use of telepresence robot for teaching in Ilorin West, Kwara State

S/N	Items	N	Mean	St.D
1	I am ready to operate a telepresence robot during Chemistry lessons.	67	1.80	0.39
2	I am ready to incorporate telepresence robots into my teaching methods.	67	1.82	0.39
3	I am ready to prepare instructional materials suited for delivery via telepresence robots.	67	1.73	0.44
4	I am ready to participate in training on the use of telepresence robots.	67	1.96	0.20
5	I am ready to troubleshoot basic technical issues with telepresence robots during lessons.	67	2.00	0.00
6	I am ready to collaborate with other teachers using telepresence robots.	67	1.96	0.20
7	I am ready to adapt my teaching to suit remote and hybrid learning via telepresence robots.	67	1.88	0.32
8	I am ready to encourage students to interact with lessons delivered through telepresence robots.	67	1.88	0.32
9	I am ready to use telepresence robots to engage students in practical Chemistry demonstrations.	67	1.83	0.37
10	I am ready to evaluate the effectiveness of telepresence robot usage in my teaching.	67	1.88	0.32
	Grand Mean		1.87	

The analysis of results on the readiness of secondary school Chemistry teachers in Ilorin West, Kwara State, to utilize telepresence robots for teaching indicates a generally low level of preparedness. The grand mean score of 1.87, which falls below the midpoint of the readiness scale, reflects that a majority of the teachers are not yet adequately positioned to integrate this technology into their instructional practices. Although relatively higher mean scores were recorded for willingness to participate in training on telepresence robots (mean = 1.96) and readiness to address basic technical issues (mean = 2.00), these still suggest that only a small fraction of the teachers display active preparedness to engage with the technology. The lowest levels of readiness were noted in aspects requiring direct pedagogical application, such as developing instructional materials tailored for telepresence robot delivery (mean = 1.73), modifying teaching strategies for remote or hybrid learning contexts (mean = 1.88), and conducting hands-on Chemistry demonstrations using the technology (mean = 1.83). These outcomes point to notable gaps in both technical competence and pedagogical adaptation, indicating that many teachers may lack the necessary expertise, confidence, or experience to employ telepresence robots effectively in classroom settings.

Similarly, low scores were observed in readiness to collaborate with colleagues using telepresence robots (mean = 1.96) and to foster active student interaction with telepresence-facilitated lessons (mean = 1.88). These findings imply that teachers' preparedness for collaborative and learner-centered engagements through this medium remains limited. The overall pattern of low mean scores suggests that, while there is some openness to professional learning opportunities, immediate large-scale adoption of the technology is unlikely without targeted interventions. In conclusion, the results emphasize that Chemistry teachers in Ilorin West are, at present, insufficiently prepared to implement telepresence robots as a teaching tool. Bridging this readiness gap will require deliberate capacity-building initiatives, practical training sessions, and progressive exposure to the technology, aimed at fostering both technical proficiency and pedagogical confidence for effective integration into science education.

Research Hypotheses

H01: There is no significant influence of gender on the awareness level of telepresence robot for teaching among secondary school Chemistry teachers in Ilorin West, Kwara State;

Table 3:

t-test of significant influence of gender on the awareness level of telepresence robot for teaching among secondary school Chemistry teachers in Ilorin West, Kwara State

Variables	Mean	St.D	St.Err.	df	t-cal.	Sig (2-tailed)
Gender	1.43	0.49	0.06	66	-46.00	0.00
Awareness	18.10	3.02	0.36	66		

The independent samples t-test revealed a statistically significant effect of gender on the awareness level of telepresence robots for teaching among secondary school Chemistry teachers in Ilorin West, Kwara State. The computed t-value of -46.00, with a significance level (p) of 0.00, falls well below the 0.05 benchmark, necessitating the rejection of the null hypothesis that gender has no significant effect on awareness. This outcome indicates that the observed difference in awareness scores between male and female Chemistry teachers is not attributable to random variation but is statistically meaningful. The mean awareness score of 18.10 (SD = 3.02) reflects a generally high level of awareness of telepresence robots among the teachers, although this awareness varied according to gender.

The negative t-value suggests that one gender group recorded lower awareness scores compared to the other, with the specific direction depending on the gender coding used in the dataset. The relatively small standard error of 0.36 reinforces the reliability and precision of the estimated mean difference. These results highlight that gender is a notable factor influencing teachers' exposure to and familiarity with telepresence robots in Chemistry instruction. Such disparities may stem from unequal access to professional development opportunities, variations in prior experience with digital innovations, or differences in enthusiasm toward emerging educational technologies. In light of these findings, it is essential for policymakers and educational stakeholders to implement awareness initiatives that are inclusive and gender-responsive. Ensuring equitable access to training and resources on telepresence robots will help bridge gender-based disparities, promote balanced participation, and enhance the effective integration of these advanced instructional technologies in Chemistry education.

H02: There is no significant influence of gender on the readiness level of telepresence robot for teaching among secondary school Chemistry teachers in Ilorin West, Kwara State.

Table 4:

t-test of significant influence of gender on the readiness level of telepresence robot for teaching among secondary school Chemistry teachers in Ilorin West, Kwara State.

Variables	Mean	St.D	St.Err.	df	t-cal.	Sig (2-tailed)
Gender	1.43	0.49	0.06	66	-66.87	0.00
Readiness	18.74	2.13	0.26	66		

The findings reveal a statistically significant effect of gender on the readiness of secondary school Chemistry teachers in Ilorin West, Kwara State, to adopt telepresence robots for instructional purposes. The computed t-value of –66.87 with 66 degrees of freedom and a p-value of 0.00 ($p < 0.05$) confirms that the observed difference in readiness between male and female teachers is unlikely to have occurred by chance. The mean readiness score for gender (M = 1.43, SD = 0.49) alongside the overall readiness score (M = 18.74, SD = 2.13) indicates that preparedness to integrate telepresence robot technology varies considerably across gender categories. The exceptionally large t-value, coupled with the statistical significance obtained, provides strong evidence to reject the null hypothesis (H_{02}), which proposed no significant gender influence on readiness levels. This outcome underscores that gender constitutes an important factor influencing the extent to which Chemistry teachers in the study area are prepared to employ telepresence robots as part of their teaching practices.

Discussions

The findings of this research offer valuable insights into the level of awareness and preparedness of secondary school Chemistry teachers in Ilorin West, Kwara State, for integrating telepresence robots into their instructional practices. The results indicate that although science remains a driving force for technological advancement and national development (George-Reyes, 2024; Howe, 2023), its influence within Nigerian secondary education is significantly shaped by teachers' familiarity with, and readiness to adopt, emerging technologies. The study revealed that teachers possessed a moderate level of awareness regarding telepresence robots. While some educators had a general understanding of the technology, many lacked in-depth knowledge of its specific functions and its potential pedagogical applications. This observation aligns with the work of Nwuke and Yellowe (2025), who emphasize that in less urbanized areas, limited exposure to advanced instructional technologies often restricts teachers' capacity to implement them effectively. Similarly, readiness levels in this study were modest, suggesting that awareness alone does not guarantee the ability to apply such tools in classroom settings without adequate training, infrastructural provision, and confidence-building measures.

The findings also suggest that awareness and readiness are not directly proportional. Even when teachers are informed about telepresence robots, readiness remains limited without structured training, institutional support, and reliable infrastructure (Natalia, 2024). While many participants expressed an openness to adopting innovative teaching methods, this willingness was constrained by practical challenges such as inadequate access to the required devices, unstable electricity supply, and poor internet connectivity—issues that were more pronounced in rural schools. These constraints are consistent with the location-based disparities reported by Ahiaku et al. (2025) and Zenda and Dlamini (2023), who note that infrastructural inequalities continue to hinder equitable integration of technology in Nigerian secondary schools. Addressing these challenges will require policy measures and resource allocation strategies that simultaneously target human capacity development and infrastructural enhancement.

With respect to gender, the results showed no significant difference in teachers' awareness or readiness to use telepresence robots. This finding contrasts with earlier studies such as Okon and

Olatunji (2024) and Akanbi and Yusuf (2022), which reported gender-related variations in ICT adoption, often linked to differences in digital literacy and confidence levels. The absence of gender disparity in the current study may reflect the growing inclusivity of ICT training initiatives within Kwara State, as well as broader societal progress toward minimizing gender bias in professional development. Nevertheless, minor differences in individual comfort levels and prior exposure to similar technologies suggest that continuous, inclusive training programs remain essential for fostering confidence across all teacher demographics (Ajayi et al., 2021).

Although this study did not statistically examine the impact of academic qualifications, descriptive analysis suggested that teachers with higher qualifications tended to possess a deeper conceptual understanding of educational technologies and a greater willingness to incorporate them into their teaching. This pattern aligns with the findings of Bitar and Davidovich (2024) and Bello and Yusuf (2022), who report that advanced academic credentials often correlate with broader pedagogical exposure and openness to technological experimentation. These observations highlight the importance of targeted professional development to bridge competence gaps among teachers with varying qualifications. Overall, the results reinforce arguments by Minsih et al. (2025) and Makinde and Oyeniyi (2024) that contemporary science education particularly in a subject as conceptually complex as Chemistry benefits greatly from interactive, technology-driven teaching methods that enhance student engagement and comprehension. The moderate awareness and readiness levels observed here indicate that, while the pedagogical case for adopting telepresence robots is compelling, practical barriers at both the teacher and institutional levels pose significant implementation challenges. This supports Wang et al.'s (2024) assertion that without context-specific research and targeted policy actions, advanced educational technologies may fail to achieve their intended impact.

Placing these findings within the wider scholarly discourse suggests that improving both awareness and readiness requires a holistic strategy. Such an approach should integrate sustained professional development, substantial infrastructural investment, and supportive policy frameworks that ensure equitable access across urban and rural contexts. This study makes a unique contribution to the Nigerian literature on educational technology integration by focusing on an emerging tool, telepresence robots within a subject-specific framework. The insights generated can inform policymakers, curriculum planners, and educational administrators in designing evidence-based strategies to ensure that Chemistry teachers are not only aware of, but also equipped to effectively utilize, technological innovations in alignment with 21st-century educational goals.

Conclusion

The findings of the study indicate that secondary school Chemistry teachers in Ilorin West, Kwara State, possess generally low levels of awareness and readiness for the instructional application of telepresence robots. Although there is some basic recognition of the concept and potential uses of this technology, substantial deficiencies persist in teachers' knowledge of its operational features, strategies for integration, and pedagogical value. Their preparedness to implement telepresence robots in classroom practice remains limited. The results further reveal statistically significant gender-based differences in both awareness and readiness, implying variations in exposure, access to relevant training, and confidence in engaging with emerging educational technologies. These disparities underscore the need for deliberate, gender-sensitive professional development programmes, adequate infrastructural provisions, and structured awareness initiatives to address existing knowledge and skill gaps. In the absence of such targeted interventions, the effective adoption of telepresence robots in Chemistry instruction may encounter considerable barriers, thereby constraining their potential to improve science education in the study area.

Recommendations

1. Since the study determined Chemistry teachers' awareness level of telepresence robots, the Ministry of Education and stakeholders should organize regular workshops and seminars to enhance their knowledge, benefits awareness, and practical application skills;
2. Based on the investigation of teachers' readiness levels for telepresence robots, schools and educational authorities should provide technical infrastructure, training, and hands-on opportunities to build skills, confidence, and preparedness for integration into Chemistry lessons;
3. Since gender significantly influenced awareness levels, awareness programs should be inclusive and gender-sensitive, ensuring both male and female Chemistry teachers have equal access to information, resources, and training on emerging technologies;
4. Given the significant gender influence on readiness levels, training should address readiness gaps between male and female teachers through targeted support to promote equitable adoption and effective use of telepresence robots.

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COMPARATIVE ANALYSIS OF THE ELECTRONIC AND TRADITIONAL COUNSELLING RECORD MANAGEMENT SYSTEM: PERSPECTIVES FROM SCHOOL COUNSELLORS IN KWARA STATE, NIGERIA

This study assesses the reliability and effectiveness of the Electronic Cumulative Record System (ECRS) in comparison to traditional paper-based methods for student record management in Kwara State, Nigeria. Data were collected from 70 practising school counsellors through a mixed-methods approach to assess accuracy, accessibility, error reduction, and user satisfaction. The findings reveal that the ECRS significantly improves data accuracy, reducing errors by 80–90%, and enhances ease of access, with all participants reporting that retrieving records electronically is "very easy." Users maintained a consistently positive attitude toward the system throughout the evaluation period, indicating high satisfaction and trust in its performance. The automated validation features of the ECRS mitigate common problems associated with manual record-keeping, such as transcription errors and file misplacement. This digital system not only streamlines administrative tasks but also empowers school counsellors to focus more on student support. The study highlights the importance of ongoing technical support, robust data privacy measures, and targeted training to ensure the sustainable adoption of educational technologies in educational settings. Findings also highlight the potential for integrating the ECRS with other educational technologies to provide comprehensive student data management. The research contributes to the growing evidence supporting digital transformation in educational administration, suggesting that electronic record systems can significantly enhance the quality and efficiency of counselling services in Nigerian schools.

Keywords: Electronic Cumulative Record System (ECRS); Student record management, Data accuracy; School counsellors; Digital transformation.

Introduction

The management of student records is a foundational component of effective educational administration and counselling services. Traditionally, many schools in Nigeria and other developing countries rely on manual, paper-based cumulative record systems to store and manage crucial student information, such as academic performance, personal details, and behavioural histories. While these conventional systems have been widely used, they suffer from notable deficiencies, including physical degradation, risk of data loss, cumbersome retrieval processes, and a high propensity for errors introduced by human handling (Ramani et al., 2025; Gbadamosi, 2025). These limitations threaten the integrity, reliability, and overall usability of student records, negatively impacting the ability of school counsellors and administrators to make informed decisions and provide timely support.

In response to these systemic challenges, digital solutions like the Electronic Cumulative Record System (ECRS) have been developed to enhance record-keeping efficiency, accuracy, and security. The ECRS offers a web-based platform designed to address the drawbacks of paper-based systems by facilitating secure, long-term storage of records, simplifying access, and enabling error reduction through automated data validation and user-friendly interfaces (Mustapha et al., 2025). The adoption of such technologies aligns with the global trend toward digital transformation in education, and particularly responds to the needs of school counselling professionals who require reliable, up-to-date information on students for effective intervention planning.

While digital record systems demonstrate considerable promise, empirical evaluation of their reliability compared to traditional methods remains essential to validate their effectiveness within specific contexts. This is especially true in settings such as Kwara State, Nigeria, where infrastructural constraints and varying levels of digital literacy present unique challenges to technology adoption and sustained use. Existing literature underscores the transformative potential of electronic records but also highlights the importance of local validation to surmount infrastructural, cultural, and operational barriers (Adio & Bolaji, 2022; Muhammad, 2024; Wani et al., 2024).

The central research question guiding this study is: How reliable is the Electronic Cumulative Record System (ECRS) in maintaining accurate student records compared to traditional methods? This question is critical because reliability underpins the value of any record-keeping system; unless records are accurate, accessible, and consistent over time, their utility for counselling, monitoring, and decision-making diminishes. The study taps into the perspectives of 70 school counsellors in Kwara State who actively utilise the ECRS, gathering both quantitative and qualitative data on system reliability, error rates, accessibility, user attitudes, and satisfaction. Preliminary findings reveal unanimous agreement on the superior reliability of the ECRS, with approximately 90% of respondents reporting an 80 to 90 per cent reduction in data errors compared to manual records (Mustapha et al., 2025).

These findings echo broader research on electronic record management in educational institutions globally. For instance, Pelekamoyo and Richard (2017) demonstrated improved record accuracy, workflow automation, and knowledge management through electronic data systems in African schools. However, this study fills an important gap by providing context-specific evidence from Nigeria, complementing work by Summey (2025) on digital education management systems and addressing country specific infrastructural and socio-cultural concerns.

Justification of the Study

The justification for this research is rooted in the urgent need to modernise student record management in Nigerian schools to overcome the pitfalls of manual record-keeping. Maintaining accurate and reliable student data is paramount for effective counselling interventions, policy formulation, and academic planning. Yet, paper-based systems remain the norm in many schools despite documented inefficiencies and risks (Ramani et al., 2025; Gbadamosi, 2025). Digital record systems like the ECRS promise to mitigate these risks, but empirical validation is necessary to confirm their real-world reliability and user acceptance within the Nigerian context.

Furthermore, given the important role school counsellors play in monitoring student progress and well-being, a reliable record-keeping system enhances their capacity to provide timely, evidence-based support. The study addresses an identified gap highlighted by Adio and Bolaji (2022), who noted low awareness and readiness among counsellors for digital counselling applications in Nigeria. By focusing on reliability, this research provides policymakers, school administrators, and software developers with actionable insights on system performance and informs strategies for wider adoption, training, and policy development.

Research Questions

1. How reliable is the Electronic Cumulative Record System (ECRS) in maintaining accurate student records compared to traditional methods?

Methodology

This study employed a mixed-methods approach, combining quantitative surveys and qualitative interviews to comprehensively assess the reliability of the ECRS compared to traditional paper-based systems. Seventy school counsellors from public and private secondary schools in Kwara State, Nigeria, participated in the research. Participants were purposively sampled based on their active use of the ECRS.

Quantitative data were collected through structured questionnaires measuring perceived reliability, frequency of errors, and ease of record retrieval. Responses were analysed using descriptive statistics to determine consensus levels and quantify error reduction rates. Qualitative data were gathered via semi-structured interviews to explore participants' experiences, attitudes toward continued ECRS use, and contextual challenges influencing system reliability.

The research design prioritised user-centred evaluation grounded in real-world usage patterns, consistent with technology acceptance frameworks (Revythi & Tselios, 2017). Ethical approvals were secured, and participant confidentiality was ensured throughout the study. The triangulation of data sources enabled robust validation of the ECRS's reliability in this context.

Results

This section presents the empirical findings from the comparative evaluation of the Electronic Cumulative Record System (ECRS) and traditional paper-based methods. Drawing on mixed-methods data collected from 70 practising school counsellors in Kwara State, the results demonstrate measurable improvements across key operational parameters. Quantitative analysis reveals significant enhancements in data accuracy and processing efficiency, while qualitative insights illuminate user experiences and system functionality. The comprehensive dataset provides robust evidence addressing the study's central research question regarding the reliability of digital versus manual record-keeping systems in educational contexts. These findings establish an empirical foundation for subsequent discussion of the ECRS's transformative potential in school counselling practice.

Research question: How reliable is the Electronic Cumulative Record System (ECRS) in maintaining accurate student records compared to traditional methods?

The study directly examines the reliability of the Electronic Cumulative Record System (ECRS) in maintaining accurate student records compared to traditional paper-based methods. Feedback from 70 school counsellors in Kwara State gathered through both quantitative and qualitative methods revealed strong support for the ECRS. Participants emphasised its advantages, noting that electronic records are "better and safer," with long-term storage and easy retrieval compared to manual systems. Quantitative data showed an 80–90% reduction in errors, while qualitative responses highlighted the system's accessibility, with counsellors describing record retrieval as "very easy." These findings demonstrate the ECRS's superior reliability, accuracy, and user-friendliness over traditional methods.

Table 1: Reliability of ECRS vs. Traditional Methods

Theme	Description	Cases (No. of participants)	Counts (Empirical indicators)	Key Evidence/Responses
Reliability	Reliability of ECRS in maintaining accurate records compared to traditional methods	70	70	"It is better and safer. It can be kept for a long time and one can go back to it easily at anytime."
Error Reduction	Extent to which ECRS reduced errors in student records	70	63	"80%, 90% respectively"
Accessibility difficulty	Ease of access to records using ECRS vs. traditional methods	70	70	"Very easy"
Changed Attitude	Did users ever change their minds during ECRS usage?	70	62	"No"
Satisfaction	Overall satisfaction with ECRS usability	70	70	"Very satisfied"

This table demonstrates that across all evaluated aspects, reliability, error reduction, accessibility, user attitudes, and satisfaction, the ECRS significantly outperforms traditional manual methods for maintaining student records. And detailed and clear summary of the Electronic Cumulative Record System's (ECRS) reliability in comparison to traditional manual record-keeping methods, based on feedback collected from 70 school counsellors in Kwara State. Firstly, the aspect of reliability is striking: every participant unanimously agreed that the ECRS is more reliable than traditional paper-based systems. Respondents emphasised that electronic records can be securely stored over long periods and accessed easily at any time, which significantly reduces the risk of data loss or physical damage typically associated with manual record-keeping. Secondly, the system has demonstrated a remarkable reduction in errors. About 63 counsellors, representing a strong majority, reported that the ECRS reduced errors in student records by approximately 80 to 90 per cent. This shows the system's effectiveness at improving data accuracy and minimising mistakes that often arise from manual data entry.

In terms of accessibility, all 70 participants described accessing student records through the ECRS as “very easy.” This reflects the user-friendly design and emphasises how electronic systems facilitate quicker, more convenient retrieval of records compared to traditional, often cumbersome, paper filing systems. Regarding the attitude towards the system, the responses revealed a stable and uniformly positive perception: no counsellors reported any shift in their opinion or trust in the ECRS during the evaluation period. This consistency suggests that users remained confident and satisfied with the system’s performance over time.

Finally, when assessing overall satisfaction, the consensus was overwhelmingly positive. Participants expressed high levels of satisfaction with the usability and functionality of the ECRS, indicating that the system effectively meets users’ needs and expectations.

Discussion

The findings of this study highlight the transformative potential of the Electronic Cumulative Record System (ECCRS) in revolutionising student record management, particularly when compared to traditional manual methods. The unanimous endorsement of the ECCRS by all 70 participating school counsellors underscores its reliability, a critical factor in educational counselling where data accuracy directly impacts decision-making and student support services. This consensus is especially noteworthy given the historical reliance on paper-based systems in Nigeria, which are prone to physical degradation, misplacement, and human error. The shift to digital records ensures long-term data preservation, mitigates risks associated with physical storage, and enables seamless access, advantages that align with global trends in educational technology adoption (Ramani et al., 2025).

One of the most striking outcomes of this research is the reported 80% to 90% reduction in data errors following the implementation of the ECCRS. This dramatic improvement in accuracy can be attributed to the system’s automated validation features, which minimize common pitfalls of manual record-keeping, such as transcription mistakes, illegible handwriting, and misplaced files. These findings resonate with broader studies on digitisation in education, including Gbadamosi (2025), who demonstrated how electronic systems eliminate redundancies and streamline administrative workflows. Furthermore, Wani et al. (2024) emphasised that digital platforms reduce cognitive load on users by automating repetitive tasks, thereby allowing counsellors to focus on higher-value interventions. The ECCRS’s success in error reduction not only enhances operational efficiency but also bolsters trust in the system, as counsellors can rely on accurate data for student assessments and reporting.

Beyond accuracy, the accessibility of the ECCRS emerged as a key strength, with all participants describing record retrieval as “very easy.” This user-friendly design is pivotal in educational settings where time-sensitive decisions, such as addressing behavioural issues or academic interventions, require immediate access to student histories. Summey (2025) corroborates this finding, noting that digital record systems significantly reduce the time spent searching for files, thereby improving productivity and service delivery. The intuitive interface of the ECCRS likely contributes to its high adoption rates, as counsellors can navigate the system with minimal training.

This accessibility is particularly beneficial in resource-constrained environments like Kwara State, where limited IT infrastructure and varying levels of digital literacy might otherwise hinder technology adoption.

The sustained positive attitude of counsellors toward the ECCRS further validates its effectiveness. Unlike technologies that face resistance or declining engagement over time, the ECCRS maintained high user satisfaction throughout the evaluation period. This aligns with the Technology Acceptance Model (Davis, 1989), which posits that perceived usefulness and ease of use are key determinants of long-term technology adoption. The consistency in user feedback suggests that the ECCRS meets these criteria, offering tangible benefits that outweigh any initial learning curve. Additionally, the iterative design process incorporating user feedback to refine the system mirrors best practices recommended by Rose and Thomas (2020), who advocate for participatory approaches in educational technology development. By involving end-users in system enhancements, the ECCRS ensures that it remains aligned with the practical needs of school counsellors.

The implications of these findings extend beyond Kwara State, offering a scalable model for other regions grappling with similar challenges in student record management. The ECCRS exemplifies how digital solutions can address systemic inefficiencies, particularly in developing contexts where manual systems still dominate. However, the long-term success of such initiatives depends on several factors, including continuous technical support, robust data privacy measures, and targeted training programs to bridge digital literacy gaps (Muhammad, 2024). Policymakers and educational administrators must prioritize these elements to ensure sustainable implementation. For instance, periodic training sessions could help counsellors maximize the system’s features, while cybersecurity protocols would safeguard sensitive student data a concern increasingly highlighted in the era of digital education (Revythi & Tselios, 2017).

Moreover, the ECCRS’s potential extends to interdisciplinary applications. For example, integrating the system with other educational tools such as learning management systems (LMS) or behavioural tracking software could provide a holistic view of student progress, enabling more personalised counselling strategies. Future research could explore such integrations, as well as the system’s adaptability to different educational tiers (e.g., primary or tertiary institutions). Comparative studies across regions with varying technological readiness would also shed light on contextual factors influencing successful adoption.

This study provides compelling evidence that the ECCRS significantly outperforms traditional record-keeping methods in reliability, accuracy, and accessibility. Its success in Kwara State underscores the transformative power of digital solutions in overcoming longstanding administrative challenges. By prioritising user-centred design, error reduction, and ease of access, the ECCRS not only enhances operational efficiency but also empowers school counsellors to deliver more effective, data-driven support. To replicate this success elsewhere, stakeholders must invest in infrastructure, training, and policy frameworks that foster sustainable digital transformation. As educational systems worldwide continue to evolve, the ECCRS stands as a testament to the potential of technology to redefine record management and improve student outcomes.

Conclusion

The study reveals that the Electronic Cumulative Record System (ECRS) is markedly more reliable than traditional manual methods in managing student records. It significantly enhances data accuracy, reducing errors by 80 to 90 per cent, while facilitating easier and more secure access to student information. The unanimous positive feedback and high satisfaction levels from school counsellors underscore the system's effectiveness and user acceptance. These results affirm that adopting a well-designed electronic record-keeping system can vastly improve record management in educational counselling, leading to better data-driven decisions and more efficient service delivery.

Recommendation

To sustain and amplify the benefits of the ECRS, it is recommended that stakeholders prioritise **ongoing training and interface simplification** aimed at enhancing usability for all counsellors, especially those with limited digital skills. This focused effort will ensure maximum user engagement, minimise operational errors, and foster widespread adoption, thereby maintaining the system's reliability and impact over time.

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SENIOR SECONDARY SCHOOL TEACHERS' PERCEPTION ON THE INTEGRATION OF VIRTUAL REALITY FOR TEACHING BIOLOGY CONCEPTS IN KWARA STATE, NIGERIA

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Abstract

Virtual reality is a computer-generated, three-dimensional environment that allows users to enter and experience a digital environment in real-time so that it feels as if they are in that environment. It was observed that concepts such as photosynthesis, respiration, enzyme activity, sex-linkages, genes, nervous system, hormones, Mendelian genetics, and nutrient cycling in nature, among others, are perceived as difficult by teachers and students in senior secondary school. The study investigated senior secondary school teachers' perception on the integration of virtual reality for teaching Biology concepts in Kwara State. Specifically, the study: (i) examined Biology teachers perceived usefulness of virtual reality for teaching; (ii) determined Biology teachers perceived ease of use of virtual reality for teaching; (iii) examined the influence of gender on Biology teachers perceived usefulness of virtual reality for teaching and (iv) examined the influence of gender on Biology teachers perceived ease of use of virtual reality for teaching.

The population for this study comprised all senior secondary Biology teachers in Kwara State. Purposively, 263 Senior Secondary Biology teachers in Ilorin metropolis were sampled. The data was analysed based on the stated research questions and hypotheses, using frequency count, mean, and t-test. The result showed that: Teachers perceived the usefulness of virtual reality for teaching Biology with a mean score 2.92; Teachers perceive the ease of use of virtual reality for teaching Biology with a mean score 3.10; there was a significant difference between male and female undergraduate perceived usefulness of online learning (.069 < 0.05); and there was no significant difference between male and female Biology teachers in perceived ease of use of virtual for teaching biology concepts (.513 > 0.05). The study concluded that the perception of Biology teachers on virtual reality for teaching Biology concepts is good. Based on the findings of the study, the study recommends that Biology teachers should endeavour to improve the use of virtual reality for teaching difficult biology concepts.

Introduction

Education is divided into two categories: teaching and learning. Teaching is the process of transmitting knowledge from a teacher to a student. Ibironke et al (2018) stated that education is a lifelong process that involves the facilitation and acquisition of knowledge from teachers to learners. There are several fields of study in education, one of which is science. Science is a field of knowledge, such as Physics, Biology, Chemistry, among others, that has been instrumental to the development of nations. Biology is one of the popular subjects out of the three natural science disciplines at secondary schools in Nigeria; the other ones are Chemistry and Physics (Jibril et al., 2015). Biology as a natural science subject is made up of disciplines, such as anatomy, botany, physiology, biochemistry, ecology and zoology (Ahmed & Lawal, 2020).

Biology is a prerequisite to study courses like medicine, nursing, pharmacology, biochemistry, agriculture, among others (Ihejiamaizu & Ochui, 2016). Knowledge of Biology plays an important role in the lives of every individual and has an increasing prominence in life. The study of Biology improves all aspects of life on earth and helps us to understand ourselves and other organisms around us (Ahmed & Lawal, 2020). In Nigeria, the objectives of the Biology curriculum are to prepare students to acquire adequate laboratory and field skills in Biology, meaningful and relevant knowledge of Biology, the ability to apply scientific knowledge to everyday life, community health, agriculture, and a reasonable and functional scientific attitude (Federal Ministry of Education, 2009). Edache et al. (2019) noted that the most difficult concepts in biology include Mendelian genetics, protein synthesis, cell division (mitosis and meiosis), genes and chromosomes, skeletal system, cellular respiration, the Calvin cycle and evolution. Ogunkunle and Onwunedo (2017) asserted that what constitutes a good teaching and learning of Biology is the use of appropriate alternative means of imparting knowledge to ensure that all important concepts are passed on to the learner.

Teaching Biology can be supported with technology tools. Educators are fast realising that the use of computer-assisted for teaching and learning is essential (Ebrahimi, 2016). The advancements in mobile and image-processing technologies have enabled students to access learning resources and receive instruction in virtual world contexts (Hwang et al., 2017). One of the advancements of technology in education, where students can receive learning in a virtual world context, is virtual reality. Virtual reality is a computer-simulated, game-based learning environment which appears real and gives learners the opportunity to interact with the learning materials and share learning experiences with teachers and other learners (Onele, 2020).

Virtual reality is a computer-generated, three-dimensional, multimedia environment. In virtual reality, participants can engage and manipulate simulated physical elements in the environment and interact with fictional or simulated components (Onele, 2020). A virtual reality is also known as immersive visualisation, which is a 3D interpretation environment. A 3D interpretation environment is an artificial virtual environment produced by computers. Virtual reality allows users to enter and experience a digital environment in real-time so that it will feel as if they are in that environment (Astuti et al., 2019). VR allows learners to acquire knowledge and skills outside the four walls of the classroom without really feeling the gap of not being in the conventional classroom system (Soetan et al., 2020). VR is an important technology tool which can be used in different levels of education to assist students in learning and building knowledge in innovative and more attractive ways (Astuti et al., 2019).

Studies have shown that virtual reality technology can be used for teaching. A study was conducted by Akgün and Atici (2022). The study found that immersive virtual reality environments had a positive, moderate effect on students' academic performance. Virtual reality can be used by the teacher to teach Biology in the classroom as a teaching material. Teaching resources are essential in education and should be used in the teaching process to ensure that the teaching process is effective. The use of suitable teaching material will effectively increase the students' interest in learning (Yusof et al., 2020). Therefore, integration of innovative technology tools like virtual reality into the teaching process might solve difficult concepts in Biology. Good teachers are constantly introducing new methods and technologies that will make teaching easier and learning meaningful to the students (Soetan et al., 2020).

Teachers are essential in integrating virtual reality into teaching. In order to assure future utilisation of VR, teachers' perception toward integrating VR as an educational tool for teaching the Biology concept is imperative. A key determinant of the success of any educational initiative is the teacher (Junaidu, 2019). It is essential to know the teachers' perception of the integration of virtual reality for teaching Biology concepts. Teachers are key players in integrating virtual reality into the classrooms. Perception is the way or which humans perceive something, which includes human senses, human experiences, and human reactions to the environment (Putra et al., 2020). Perception is a feeling taken after experience through the interpretation of a stimulus recorded in the brain by more than one sense organ (Ajijola et al., 2021). From the above, perception can therefore be the way humans understand the knowledge and represent it from their point of view. Putra et al (2020) investigated the English teachers related to perception towards virtual reality as a learning media in Singaraja. The result showed that the teachers' perception of virtual reality in general was very positive. Wells and Miller (2020) examined teachers' opinions about virtual reality technology in school-based agricultural education. Results indicated the teachers generally held favourable opinions about VR technology, intertwined with a considerable degree of uncertainty about the technology and its uses.

One variable that can influence teachers' perception of teachers towards integration of technology for teaching is gender. The term gender refers to a wide range of biological, behavioural, physical and mental characteristics regarding differences between the female and the male population (Adigun et al. 2015). Anaza (2017) noted that gender differences in the use of technology should be carefully examined, rather than merely demonstrating differences. The influence of gender in classroom utilisation of technology also plays a major role in the selection, development and performance of instructional objectives (Soetan et al., 2020). Emeka (2015) study found that there was no effect of gender on lecturers' perception of the utilisation of modern technology. Abdullahi (2020) deduced that gender does not influence the adoption of virtual laboratories for teaching among physics teachers. Soetan et al (2020) study established that there was no significant difference between male and female teachers' awareness of virtual reality for instructional purposes.

The integration of virtual reality for teaching might address the issues of difficult concepts in Biology. It was observed in the studies of Etobro and Fabinu (2017); Chukwuemeka and Dorgu (2019); and Haruna, (2021) that photosynthesis, respiration, enzyme activity, dominance and codominance, sex-linkages, genes and chromosomes, mitosis and meiosis, nervous system, hormones, Mendelian genetics, nutrient cycling in nature, ecological management, conservation of natural resources, pests, diseases of crops and reproductive system in plants are concepts in Biology that are perceived as difficult by teachers and students in senior secondary school. Also, these concepts are regarded as being at an abstract level in biology in the curriculum. As a result, students will lack the required knowledge and skills in learning Biology.

Also, it was observed that teachers used pictures to teach some of these concepts. However, pictorial representation is inadequate for teaching on topics such as cells, blood circulation, hormones, genes, chromosomes, nervous system, mitosis, meiosis and others. Danso (2016) explained that the difficult topics in Biology were characterised by complex terms and vocabulary;

the abstract nature of the topics, the broad nature of the topics; teachers not conducting practical laboratory work but teaching theoretically and a lack of teaching/learning resources, and teachers' failure to cite practical examples students can relate with.

Therefore, it is essential to have technology that can be used to teach those concepts. Sarioglu and Girgin (2020) carried out a study on the effect of using virtual reality in 6th-grade science courses, the cell topic on students' academic performance and attitudes towards the course. The results of this research revealed that virtual reality technology has a positive effect on students' academic performance. Despite several studies on virtual reality, no studies exist relating to Biology teachers' perceptions on the integration of virtual reality for teaching. Therefore, this study investigated senior secondary school teachers' perception on the integration of virtual reality for teaching Biology concepts in Kwara State.

Purpose of the Study

The main purpose of the study was to find out senior secondary school teachers' perception on the integration of virtual reality for teaching Biology concepts in Kwara State. Specifically, the study:

1. Examined teachers' perceived usefulness of virtual reality for teaching Biology.
2. Determined Biology teachers perceived the ease of use of virtual reality for teaching.
3. Examined the influence of gender on Biology teachers' perceived usefulness of virtual reality for teaching.
4. Examined the influence of gender on Biology teachers' perceived ease of use of virtual reality for teaching.

Research Questions

Based on the purposes raised above, the following research questions were raised and answered in this study.

1. What are the teachers' perceived usefulness of virtual reality for teaching Biology?
2. How do teachers perceive the ease of use of virtual reality for teaching Biology?

Research Hypotheses

The following null hypotheses were raised and tested in this study;

H_{01}: There is no significant difference in Biology teachers' perceived usefulness of virtual reality for teaching Biology concepts based on gender

H_{02}: There is no significant difference between male and female Biology teachers in perceived ease of use of virtual reality for teaching biology concepts

Methodology

The study adopted a descriptive research design of a survey type. The population for this study comprised all senior secondary Biology teachers in Kwara State, and the target population were all Senior Secondary Biology teachers in Ilorin metropolis. Purposively, the study sampled Biology teachers in Ilorin. 263 Senior Secondary Biology teachers were sampled in this study. Purposive sampling was used because only senior secondary schools that have ICT facilities were considered for this study. A researcher-designed questionnaire titled "Senior Secondary School Teachers' Perception on the Integration of Virtual Reality for Teaching Biology Concepts in Kwara State" was used to elicit information from the respondents on the integration of virtual reality for teaching Biology Concepts.

The instrument was validated by three Educational Technology experts to determine the face and content validity of the instrument being used for this study. In order to determine the internal consistency of the questionnaire, the instrument was pilot-tested on Biology teachers in another local government, which is not part of the study sample. The internal consistency reliability method was used in getting responses from the pilot sample. The data obtained in the reliability test was subjected to Cronbach to determine the internal consistency of the questionnaire. The result yielded a 0.88 coefficient of reliability.

The researcher proceeded to the secondary schools with an introductory letter and solicited permission from all appropriate authorities of the sampled schools. The researcher personally administered the questionnaire to the Biology teachers in the sample secondary schools with the help of a research assistant. During the process of this research, ethical issues were considered, and the respondents were permitted to participate in the study voluntarily without being coerced. Information gathered during this study was handled with utmost confidentiality so that when reporting the findings of the participants' identities would not be disclosed. The researcher ensured that all cited works are referenced and acknowledged to avoid plagiarism. The data was analysed based on the stated research questions and hypotheses, using frequency count, mean, and an independent sample t-test.

Results

Table 1: What is the teachers' perceived usefulness of virtual reality for teaching Biology?

Items	Mean
1. Using virtual reality in teaching Biology would enable me to break the barrier of abstract concepts	3.31
2. Using virtual reality would improve my teaching performance	3.15
3. As a teacher, using virtual reality for instruction would increase my productivity	3.22
4. Using virtual reality would enhance my teaching	3.04
5. Using virtual reality would make it easier to teach abstract concepts in Biology	3.18
6. I feel that using virtual reality for teaching will be beneficial to my teaching experience	2.51
7. I am comfortable using a virtual reality tool for teaching Biology in the classroom.	2.64
8. Virtual reality is very useful for displaying video content	2.86
9. Virtual reality is very effective for teaching Biology	2.63
10. Through virtual reality, students focus their senses on the teaching topic	2.75
Grand mean	**2.92**

To examine how teachers perceived the usefulness of virtual reality for teaching Biology, as stated in research question 1, and as shown in Table 1. The mean score for each of the question items is listed in the last column of the table. The average mean score for each of the items is 2.50. The average mean score of 2.50 was calculated by adding up each value of the 4-point Likert scale and divided by 4 (Strongly Agree = 4, Agree = 3, Disagree = 2, and Strongly Disagree = 1. 4+3+2+1=10 divided by 4 = 2.50. Item 1 has the highest mean score of 3.31, which is greater than the average mean score (2.50), and item 6 has the lowest mean score of 2.51, which is also greater than the average mean score (2.50). The grand mean of the entire item is 2.92, which is greater than the 2.50 average mean score. This implies that Biology teachers perceived the usefulness of virtual reality for teaching Biology concepts.

Table 2: How do teachers perceive the ease of use of virtual reality for teaching Biology?

Items	Mean
1. I feel that virtual reality is not difficult to operate	3.22
2. I feel that using virtual reality would be easy for me	3.00
3. I find virtual reality tools flexible for interacting with	3.09
4. Learning to operate virtual reality was easy for me	3.31
5. I do not encounter any technical problems when using virtual reality	2.99
6. I can easily connect virtual reality to my phone	2.94
7. I feel comfortable using my smartphone with virtual reality	2.92
8. I find virtual reality flexible for interacting with	2.86
9. I am becoming an expert at using virtual reality	3.14
10. I am motivated to use virtual reality in the classroom with my students	3.24
Grand mean	**3.10**

To find out if Biology teachers perceive the ease of use of virtual reality for teaching, as stated in research question 2, and as shown in Table 2 above. The mean score for each of the question items is listed in the last column of the table. The average mean score for each of the items is 2.50. The average mean score of 2.50 was calculated by adding up each value of the 4-point Likert scale and divided by 4 (Strongly Agree = 4, Agree = 3, Disagree = 2, and Strongly Disagree = 1. 4+3+2+1=10 divided by 4 = 2.50. Item 10 has the highest mean score of 3.24, which is greater than the average mean score (2.50), and item 8 has the lowest mean score of 2.86, which is also greater than the average mean score (2.50). The grand mean of the entire item is 3.10, which is greater than the 2.50 average mean score. Therefore, it can be established that Biology teachers perceive the ease of use of virtual reality for teaching.

Hypothesis Testing

H_{O1}: There is no significant difference between male and female Biology teachers' perceived usefulness of virtual reality for teaching Biology concepts based on gender.

Table 3: Independent Sample t-test showing significant difference between male and female Biology teachers' perceived usefulness of virtual reality for teaching Biology concepts.

Gender	N	X	SD	Df	T	Sig. (2-tailed)	Decision
3. Male	89	45.91	6.55	261	-1.826	.069	Rejected
4. Female	174	44.14	6.35				

From Table 3, it can be deduced that there was a significant difference between male and female Biology teachers' perceived usefulness of virtual reality for teaching Biology concepts based on gender. This is reflected in the result: t (261) = -1.826, $p < 0.05$. That is, the result of the t-value of -1.826, resulting in a 0.069 significance value, which is less than the 0.05 alpha value. Thus, the null hypothesis is rejected. This implies that there was a significant difference between male and female Biology teachers' perceived usefulness of virtual reality for teaching Biology concepts.

H_{O2}: There is no significant difference between male and female Biology teachers in perceived ease of use of virtual for teaching biology concepts.

Table 4: Independent Sample t-test showing significant difference between male and female Biology teachers in perceived ease of use of virtual reality for teaching biology concepts

Gender	N	X	SD	Df	T	Sig. (2-tailed)	Decision
Male	89	45.98	7.99	261	-.656	.513	Not Rejected
Female	174	45.34	6.42				

From table 4, it can be deduced that there was no significant difference between male and female Biology teachers in perceived ease of use of virtual for teaching biology concepts. This is reflected in the result: t (261) = -.656, p > 0.05. That is, the result of the t-value of -656 resulting in a .513 significance value, which is greater than the 0.05 alpha value. Thus, the null hypothesis is accepted. This implies that there was no significant difference between male and female Biology teachers in perceived ease of use of virtual reality for teaching biology concepts.

Discussion

Findings from the study revealed that teachers perceived the usefulness of virtual reality for teaching Biology concepts. The result disagreed with Wells and Miller (2020), that the teachers held opinions about VR technology intertwined with a considerable degree of uncertainty about the technology and its uses. But the study agreed with the Alfalah et al (2017) study on perceptions toward adopting virtual reality as a learning tool in information technology. The results showed that the end users are willing to adopt VR systems as a teaching tool. The finding conforms with Khukalenko et al (2022) study on teachers' perceptions of using virtual reality technology in classrooms. The study showed that teachers had moderately positive perceptions toward the use of VR for instruction. Similarly, the result of this study supported Putra et al (2020) findings that the teachers' perception toward virtual reality in general was very positive.

The result of this study indicated that Biology teachers perceive the ease of use of virtual reality for teaching. The findings support Jones et al (2015) on middle school teachers' and students' perceived presence after learning science with a virtual reality system. The result indicated that teachers rate the virtual reality experience as realistic. This implies that both teachers and students perceived the ease of use of virtual reality as viable for instruction. The study is also in agreement with the result of Onuoha and Jolaosho (2021) that economics teachers perceived the influence of virtual reality economics on students' performance.

Furthermore, several studies have investigated the sociodemographic factors on teachers' concerns about the integration of new technologies in education. Gender differences were investigated. The result showed that there was a significant difference between male and female teachers' perceived usefulness of virtual reality for teaching Biology concepts. The findings align with the findings of Antón-Sancho et al. (2022) on the perspective of science professors' didactic use of virtual reality in Colombian Universities. The study found that there are differences in perceptions of virtual reality's usefulness for teaching between male and female university professors in Colombia. The result of this study revealed that there was no significant difference between male and female teachers in perceived ease of use of virtual reality for teaching biology concepts. The result of the study disagreed with the study by Dirin et al. (2019) on gender differences in perceptions of conventional video, virtual reality and augmented reality. The findings revealed that there are significant differences in male and female teachers' perceived usefulness of virtual reality.

Conclusion

Based on the findings the study concluded that Biology teachers perceived the usefulness of virtual reality for teaching Biology concepts; Biology teachers perceived the ease of use of virtual reality for teaching; there was a significant difference between male and female teachers perceived usefulness virtual reality for teaching biology concepts; and there was no significant difference between male and female Biology teachers in perceived ease of use of virtual reality for teaching biology concepts.

Recommendations

Based on the result of this study, the study recommends that:

Biology teachers should endeavour to improve the use of virtual reality for teaching difficult concepts in Biology.

4. Biology teachers should integrate technology tools like virtual reality for teaching Biology concepts at secondary school to improve students' learning outcomes in the subject.
5. Biology teachers, both male and female, should develop more interest in using virtual reality for teaching.
6. Biology teachers, both male and female, should endeavour to have ICT skills as this will aid the ease of use of virtual reality.

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POST GRADUATE STUDENTS' AWARENESS AND SELF-EFFICACY OF USING ACADEMIC SOCIAL NETWORKING SITES IN NORTH CENTRAL NIGERIA

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Abstract

Academic Social Networking Sites (ASNSs), including platforms like Academia.edu, ResearchGate, and LinkedIn, are dedicated tools aimed at facilitating academic collaboration, the dissemination of research, and professional networking. This study examines postgraduate students' awareness of and self-efficacy in utilizing academic social networking sites within North-Central Nigeria. Two research questions guided the study and were addressed descriptively through a cross-sectional survey involving 646 postgraduate students, purposively selected from nine universities across Kwara, Kogi, and Niger States. A researcher-designed questionnaire titled "investigating postgraduate student's awareness and self-efficacy in using academic social networking sites in North-central Nigerian" was administered through Google form to elicit responses from the sampled postgraduate students. The data collected were analyzed using descriptive statistics. The level of significance was set at <0.05. The respondents from federal universities constituted 51.2% of the population, those in state universities made up 37.5% of the respondents while the private universities are 11.3%. Analysis of the result revealed that the level of awareness of ASNS was high, with a mean score of 3.09, while the level of self-efficacy was moderate (mean = 2.91). In conclusion, the findings highlighted the importance of promoting awareness and self-efficacy among postgraduates towards ASNS to improve academic networking and academic collaborations.

Keywords: *Awareness, self-efficacy, postgraduate, Academic Social networking sites*

Introduction

In general context, awareness can be described as the state or ability to perceive, to feel, or to be conscious of events, objects, or sensory patterns. The perception or the understanding may be of internal or external stimuli, and can either be about specific things or in a general way. Awareness exist in different dimensions and levels, these include self-awareness, situational awareness, emotional awareness, digital awareness, information awareness, global awareness and cultural awareness depending on the contexts ones need it for (Orr, 2023). These different awareness types promote a collaborative and knowledge-sharing atmosphere in the setting of academic social networking, which facilitates meaningful connections and enhances users' overall academic experiences. Although there are limited references for each sort of awareness on academic social networking sites, more general research on academic networking, online collaboration, and the usage of social media in educational settings supports their importance and relevance.

The awareness of academic social networking sites (ASNSs) is not as popular as the awareness of general Social media such as Facebook, LinkedIn, WeChat among the general others. Fewer individuals outside academic community are aware of their existence and usefulness, notwithstanding their increasing awareness in the academic circle, where they are being used for connecting with other students, academics and researchers and for their ability to be used for sharing scholastic work and collaboration on projects and researches (Hailu, 2021). In a study that investigated the awareness and usage of ASNS among library and information science professionals in India, by Stephen and Pramanatha (2021), it was revealed that the level of awareness of ASNS was relatively low among the general public, with only 40% of respondents had ever heard of an ASNS (Stephen, 2021). In their study, the most popular ASNS was ResearchGate, this was followed by Academia.edu and Google Scholar (Stephen, 2021). The predominant body of research focuses on the awareness levels of specific stakeholders, such as students, lecturers, academics, and researchers, on ASNSs, with fewer studies addressing the broader population's understanding of ASNSs (Jain, 2022). In a study among female academics in a university in India, K Sripathi found that Google Scholar was the most popular ASNS among the respondents (Sripathi, 2024). Also, most of the female scholars use at least one ASNS handle. Source of awareness were through friends, and colleagues. They make use of these sites to search for articles and also to disseminate their work. The main obstacle to the use of ASNS were lack of awareness about these sites (Sripathi, 2024). A study conducted by Ishola, et al. (2019) in Oyo State found that most postgraduate students were not fully aware of these platforms, despite their potential benefits for research collaboration and academic interaction (Ishola, 2020).

Awareness of academic social media sites (ASNs) among academic staff is better possibly because of the usefulness of ASNS for research sharing, collaboration among students and lecturers, and improved communication and feedback within the academic community. These are possibly some of the reasons why the level of awareness among students is increasing in recent years. A study by Ali, et al, (2022) reported that 96% of researchers had high level awareness of at least one ASNS and 81% used them regularly (Ali, 2022). While looking at the awareness of specific ASNS among academic staff in Egypt, El-Berry (2015) showed that 90% were aware of Academia.edu, 89% were conversant with LinkedIn, 88% were aware of ResearchGate, and about 85% of them had knowledge of Google Scholar (El-Berry, 2015). Also a study conducted at Tamil Nadu's universities, India by Jeyapragash and Arputharaj (2017) found that, majority of respondents have a medium level of awareness ASNS (Jeyapragash, 2017). They also highlighted the degree of awareness on ASNS as regards the age and qualifications of the respondents. The study revealed that the majority of the studied academics explored web resources extensively in order to be adequately familiarized with ASNS.

The fundamental function of ASNSs is to facilitate connections among students and promote collaboration on assignments and projects, which may be a principal reason for students' awareness of these platforms. This will facilitate their work and improve finding academic supports (Megwalu, 2022). Students with greater exposure and knowledge in the use of these Academic Social Media sites have better chance of attaining academic successes. This is because they have access to more information and academic resources such as course material, question banks, articles and journal as well as experts' opinions. It also exposes them to better and easier ways of communicating with colleagues, lecturers and experts in various field of endeavor. This assists them in asking relevant questions from their supervisors and lecturers, discussion on the courses and projects and ways to do their assignments (Valdez, 2020).

Self-efficacy fundamentally refers to an individual's confidence in their capacity to succeed in a specific task or achieve a particular goal. It is also understood as the belief in one's capacity to perform behaviors necessary to achieve designated outcomes. Albert Bandura, a psychologist and the originator of social cognitive theory, identified self-efficacy as a central component of his framework. According to Bandura, self-efficacy is defined as individuals' appraisals of their capacities to organize and conduct actions required to reach certain results (Bandura, 1997). Self-efficacy is not just believing that one is capable of attaining success; it involves the belief that one is capable of taking the required steps to achieve that success (Sarman, 2025).

The self-efficacy as regards Social networking sites usage was described by Almarwaey (2017) as the suitable theory that gives an insight into an effectiveness of using SNS on Academic students' beliefs and performance (Almarwaey, 2017). Almarwaey (2017) carried out a study among students of Umm AL-Qura University, Mecca, utilizing a questionnaire to gather information of 286 participants assessing the reasons for using academic social networking sites (Almarwaey, 2017). The major findings on the utilization of social networking sites pertained to communication with colleagues and the dissemination of educational materials. A significant positive correlation existed between the utilization of ASNSs and students' self-efficacy (Almarwaey, 2017).

Self-efficacy influences several human behaviours essential for achieving success, such as setting achievable goals, making choices in activities conducive to success, putting in appropriate efforts towards goal attainment, and maintain consistency and persistence in those efforts even when confronted with obstacles, until the goals are achieved (Schunk, 2021). Other behaviors that are affected by self-efficacy are using ones past experience into use, emulating or following steps taken by those that had succeeded in similar terrain, using words of encouragement from others to boost one's performance and having feeling that one is in good frame of mind to succeed. All the above are behaviors commonly found among people with strong self-efficacy (Schunk, 2021).

Self-efficacy is not static but changes depending on situation and period. It is also modified by experience and acquisition of new knowledge and skills (Pabis, 2025). Researchers have enumerated some factors that may improve self-efficacy of students. Such factors are setting of realistic and realizable goals as too difficult goals may lead to failure thereby reducing self-efficacy. Challenging oneself is another way through which self-efficacy can be improved upon. Students that dread challenges may find it difficult to improve their self-efficacy. Challenging oneself on new tasks may help students to perfect the tasks. And in case, there are failures and mistakes, learning from such mistakes can later be a building bricks that will help the students perfect their self-efficacy. Students should also not be afraid of asking for supports. Supports can be from co-students, family, lecturers and experts. These are factors that help individuals to improve their self-efficacy. Hence, self-efficacy is considered to be a key ingredient for students to succeed in their academic work (Puozzo, 2021).

Numerous studies have looked into the connection between academic self-efficacy and social networking sites. But the results have been inconclusive. Some research have detected a favorable association, some showed a negative relationship, while some found no significant correlation between the usage of social networking sites and academic self-efficacy. According to Boahene et al. (2019), students' academic self-efficacy and their usage of social media for learning are positively correlated at Ghanaian public higher education institutions (Boahene, 2019). Students' academic self-efficacy was evaluated using their cumulative grade point averages (CGPA) from the previous academic year, and the frequency and duration of their social media use were ascertained by counting the number of hours they spent on social media each day. Their findings suggested that the usage of social networking sites for educational activities was favorably connected with academic performance, with academic self-efficacy playing a substantial mediating role in further increasing students' academic success (Boahene, 2019).

While reviewing the relationship between self-efficacy on the use of online platforms for academic purposes, Alqurashi (2016) identified four main areas of self-efficacy has been important (Alqurashi, 2016). They are;1 computer self-efficacy, 2, Internet self-efficacy, 3,information-seeking self-efficacy and 4, Learning Management Systems (LMS) self-efficacy which are all domicile in the domain of technological factor (Alqurashi, 2016). Other areas of self-efficacy are learning factor and general self-efficacy on Social Media usage. Computer self-efficacy was found to have an important role to play on students' satisfaction with online courses whether presently or in future, Internet self-efficacy is associated with student performance and satisfaction with online learning and LMS self-efficacy has impact with hybrid classes but not with purely online classes (Boahene, 2019). Similar to the study by Alqurashi (2016), another study on self-efficacy and online teaching using platforms such as Social Networking sites by Prifti (2022), reveals a strongly positive relationship between LMS and self-efficacy in the use of social media (19,20). Students found satisfaction in their study when hybrid method of teaching is used. These findings indicated that an improvement in technological self-efficacy leads to increase academic satisfaction (19,20). Eom, (2012) came to similar conclusion with the finding that learners' self-efficacy was a factor that determine the effectiveness of blended learning courses that included physical and virtual classes (Eom, 2012).

The self-efficacy of students and academic social media sites (ASNS) have an intertwined relationship. ASNS have been shown to positively affect self-efficacy by enhancing students' academic performance. Students with good knowledge of the use of ASNS tend to achieve better grades because ASNS help them collaborate with others in their studies and projects. They also perform better in examinations than students who do not use ASNS (Kouser, 2020). In other words, students with high self-efficacy are more likely to engage with ASNS than those with low self-efficacy, as they are confident in their ability to use ASNS effectively (Adeniyi, 2016).

Researchers have documented factors that make the ASNS improve students' self-efficacy as follows; Perceived usefulness: Students who perceive ASNS as being useful in their academic work are likely to use them more than those who do not considered them useful. With regular use, students' self-efficacy will be increased (Chen, 2022). Also ease of use: Students have different views about how easy it is to use ASNS. It is reported that students who find ASNS to be easy to use tend to use them more frequently and this help them to improve their self-efficacy (Deng, 2019). Social support: It has been said several times that ASNS help students to collaborate with their colleagues and supervisors in the academic community. This invariably improve their performance academically and boost their belief and self-confidence hence, they experience increased self-efficacy (Deng, 2019). Positive feedback through appropriate use of ASNS, students get regular feedback from other students and lecturers. These feedbacks help them to identify their areas of strengths and weaknesses which good students can make use of to improve their performance. Students who receive positive feedback rather than negative feedbacks on ASNS tend to have increased self-efficacy (Chen, 2022). Opportunities for mastery students have to get access to wide variety of academic material as well as array of new skills through ASNS, which ultimately positively impact on their self-confidence to succeed, hence tend to have increased self-efficacy.

Though it has been shown that ASNS help students develop their self-efficacy, it should not be forgotten that there are negative impacts of ASNS on self-efficacy. When used inappropriately, ASNSs can be source of distractions to students who may neglect their primary aim and concentrate on irrelevancies on ASNS. This may likely lead to poor academic performance and hence cause low self-confidence and lead to low self-efficacy. Another way the ASNSs can reduce students' self-efficacy is through negative feedbacks, which may be unhelpful to the students but instead discourage them to take appropriate steps to improve themselves. It is, therefore, essential for students to identify both positive and negative effects of ASNSs on their academic activities in order to be able to get the best from these sites as it relates to students' self-efficacy. It has been shown that students' self-efficacy on ASNS improves their Academic performance, no effort should therefore be spared to enhance this self-efficacy. Lectures as well as the academic institutions have several may to encourage their students in regular use of ASNS which will later lead to improvement in self-efficacy

Purpose of the study

This study examined the awareness and self-efficacy related to academic social networking sites among postgraduate students in North-Central universities in Nigeria. Specifically, it evaluated their level of awareness and assessed the self-efficacy associated with the use of academic social networking sites (ASNSs) among postgraduate students in North-Central Nigeria.

Research Questions

The study addressed the research questions raised:

1. To what extent are postgraduate students in North-Central Nigeria aware of academic social networking sites?
2. What is the self-efficacy level regarding the use of academic social networking sites among postgraduate students in North-Central Nigeria?

Methodology

This study employed a descriptive research design using a cross-sectional survey approach, with data collected through a questionnaire distributed via Google Forms. It focused on exploring the awareness and self-efficacy of postgraduate students in using academic social networking sites across North-Central Nigeria. The study population included all postgraduate students enrolled in universities within the North-Central Geopolitical Zone, covering Kwara, Kogi, Plateau, Nasarawa, Niger, and Benue States. However, the target group was specifically postgraduate students from universities in three purposively selected states: Kwara, Kogi, and Niger. The target population figure is 646. The demographic information of the respondents and the results of the analysis are presented in tables and figures.

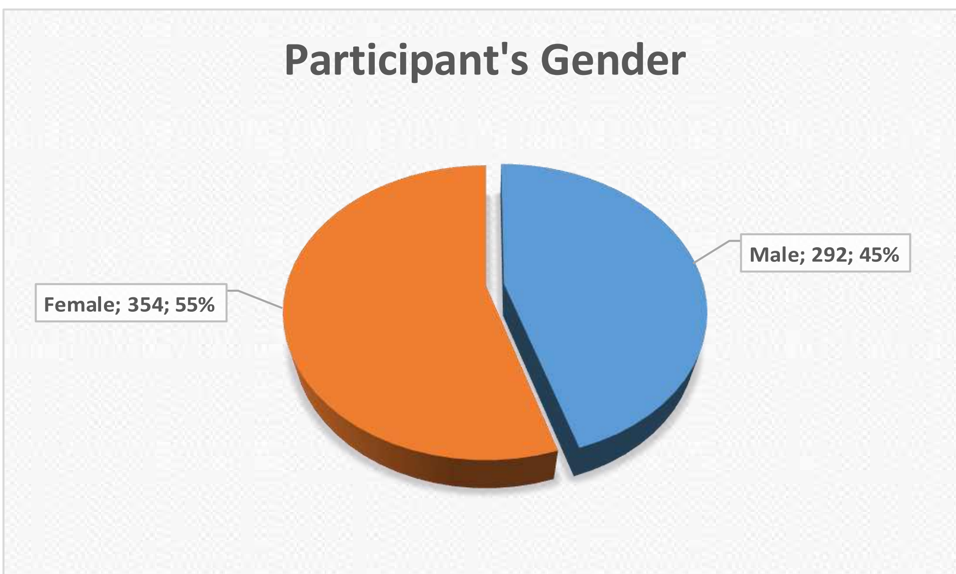

Figure 1: Distribution of respondents based on gender

Figure 1 shows the gender distribution of the respondents. Out of the total 646 respondents, 354 (55%) are female, while 292 (45%) are male. This reflects a slightly greater representation of females in the sample.

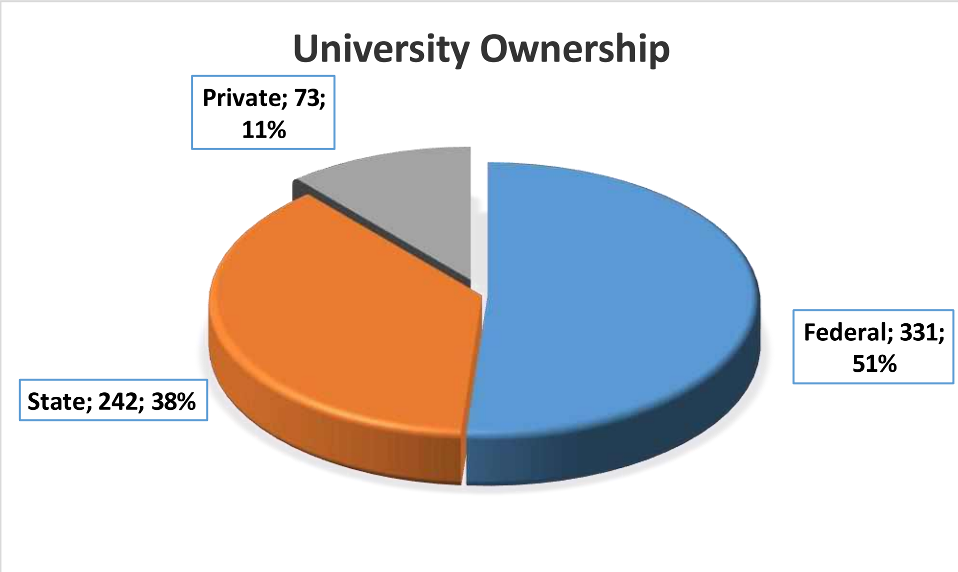

Figure 2: Distribution of respondents based on university ownership

Figure 2 illustrates the distribution of respondents based on the ownership of the University they are affiliated with. Among the 646 respondents, the majority, 331 respondents (51%), are from federal institutions. state institutions make up of 242 (38%) of the respondents, while private institutions have the smallest representation with 73 (11%).

Research question 1: To what extent are postgraduate students in North-Central Nigeria aware of academic social networking sites?

Table 1

The extent of postgraduate students' awareness of academic social networking sites in North-Central Nigeria

S/N	Item	Mean
1	I am aware that there are different types of academic social networking sites (ASNS) relevant to my field of study.	3.27
2	I am aware that there are potential benefits in using ASNS for academic collaboration.	3.16
3	I am aware that there are specific features offered by different ASNS platforms.	3.03
4	I am aware that there are relevant groups on ASNS for my academic interests.	3.03
5	I am aware that there are etiquette for engaging with others on ASNS in an academic context.	3.07
6	I am aware that there are challenges associated with using ASNS for academic purposes (e.g., data privacy, misinformation).	3.02
7	I am aware that one can always distinguish between reliable academic information sources on ASNS.	3.12
8	I am aware that there are resources available at my university to help me use ASNS effectively	3.01
	Grand mean	**3.09**

Table 1 presents information on the level of awareness of postgraduate students in North-central Nigeria regarding Academic Social Networking Sites (ASNS). The result reveals that item 1 recorded the highest mean score of 3.27, suggesting that the majority of postgraduate students are familiar with various types of academic social networking sites (ASNS) related to their areas of study. This was followed by item 2 with a mean score of 3.09, which indicates that postgraduate students are aware that there are potential benefits in using ASNS for academic collaboration. The item with the lowest mean score of 3.01 was item 8, which inquired if postgraduate students are aware of resources available at their universities for them to use ASNS effectively. The grand mean score for awareness of ASNS by postgraduate students in north-central Nigerian university was 3.09 which is greater than the benchmark of 2.50 (since it is a 4 Likert scale response mode). This shows that level of awareness of postgraduate students of Academic Social Networking Sites in North-central, Nigeria is high.

Research question 2

What is the self-efficacy level regarding the use of academic social networking sites among postgraduate students in North-Central Nigeria?

Table 2

Self-efficacy levels in the use of academic social networking sites among postgraduate students in North-Central Nigeria

S/N	Item	Mean
1	I possess the knowledge to create a profile on Academic Social Networking Sites (ASNS) (e.g., ResearchGate, Academia.edu)	2.82
2	I am confident in my ability to share my research work on ASNS.	2.95
3	I can effectively use ASNS to network with other researchers.	2.85
4	I am capable of following current research trends on ASNS.	3.04
5	I can utilize ASNS to connect with potential collaborators for research projects.	2.77
6	I am confident in my ability to join and participate in academic groups and forums on ASNS.	2.80
7	I can use ASNS to search for professional events such as conferences, workshops and training.	3.03
8	I am able to tract and impact the citations of my work through ASNS analytical tools.	2.98
9	I can utilize supplementary academic resources such as papers and articles on ASNS.	2.97
10	I am confident in my ability to manage privacy and security settings to protect my academic work on ASNS.	2.91
	Grand mean	**2.91**

Table 2 assesses self-efficacy levels in the use of academic social networking sites among postgraduate students in North-Central Nigeria. The result shows that item 4, which assessed the capability of postgraduate students to follow current research trends on ASNS, has the highest mean score of 3.04. This was closely followed by item 7 with the mean score of 3.03. This item assessed the ability of postgraduate students to use ASNS to search for professional events such as conferences, workshops and training. However, item 5 that inquired if the students can utilize ASNS to connect with potential collaborators for research projects has the lowest mean score of 2.77. The grand mean for the questionnaire assessing the efficacy of postgraduate students on ASNS was 2.91. This indicates that the level of self-efficacy of the respondents was moderate, because it was slightly above the benchmark of 2.50.

Discussion

This study explored the awareness and self-efficacy regarding academic social networking sites among postgraduate students in universities across North-Central Nigeria. The first research question aimed to assess the postgraduate students' level of awareness of these platforms. The findings revealed a high level of awareness among the students, consistent with previous studies that reported similar awareness levels among students in other regions (Nse Akwang , 2022). The moderate level of self-efficacy perceived by students regarding ASNS usage is consistent with the findings of Almarwaey (2017), which demonstrated a positive correlation between SNS usage and academic self-efficacy (Almarwaey, 2017). This study did not find any significant relationship between self-efficacy and usability, which is contrary to the positive impact reported by Boahene et al. (2019) (Boahene, 2019). Alqurashi (2016) also identified various types of self-efficacy affecting online learning, including computer and LMS self-efficacy, which can explain the diverse perceptions of self-efficacy reported in this study (Alqurashi, 2016).

Conclusion

This study investigated the awareness and self-efficacy of Academic Social Networking sites among Postgraduate students in North-central Universities in Nigeria. The finding revealed that postgraduate students in North-central Nigeria demonstrated a moderate level of awareness and confidence in their ability to use academic social Networking Sites (ASNS). Since the level of awareness was high among postgraduate students, universities in North-Central Nigeria could consider integrating ASNS more formally into academic programs to take advantage of this awareness for academic networking and collaboration. The moderate self-efficacy levels among postgraduate students suggest a need for targeted training sessions to build confidence and proficiency in ASNS usage, which could also enhance students' academic networking capabilities. Similarly, there should be organization of workshop and seminar programs that will enlighten the students on the level of awareness and self-efficacy among postgraduate students in North-Central universities.

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SCHOOL OWNERSHIP AND SCHOOL LOCATION AS PREDICTORS OF BOOLOGY TEACHERS ICT COMPETENCE ON PEDAGOGICAL APPROACHES IN NORTH-CENTRAL, NIGERIA

BY

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Abstract

The rapid pace of technological innovation in the 21st century has made the adoption of Information and Communication Technology (ICT) an indispensable component of quality teaching and learning. In the field of Biology education, teachers' proficiency in ICT is central to enriching instructional strategies, boosting learner participation, and enhancing academic achievement. This study investigated how school ownership and location predict the ICT competence of Biology teachers and influence their pedagogical practices in North-Central Nigeria. A descriptive cross-sectional survey design was adopted, targeting 696 Biology teachers from Federal and State senior secondary schools across six states and the Federal Capital Territory. Sampling was conducted in multiple stages, combining random, stratified, and proportional techniques to ensure balanced representation by qualification and location. Data were gathered using a validated questionnaire with high reliability indices (Cronbach's Alpha: ICT competence = 0.71; pedagogical approaches = 0.83). Findings revealed that teachers regularly incorporated multimedia resources, online simulations, inquiry-based learning, formative assessment, and laboratory experiments into their lessons. Conversely, differentiated instruction and activities designed to cultivate critical thinking were less frequently applied. T-test analysis showed statistically significant differences in pedagogical approaches based on both school ownership and location ($p < 0.05$), indicating that institutional type and geographical setting influence instructional choices. The study recommends targeted, context-specific professional development, particularly in ICT integration, to reduce disparities and foster innovative, equitable teaching across urban and rural school environments.

Keywords: ICT competence, pedagogical approaches, school ownership, school location, Biology education

Introduction

In an era characterized by rapid technological advancements, the integration of Information and Communication Technology (ICT) in education has become imperative to enhance teaching and learning experiences. For Biology educators, proficiency in ICT competence and skills is critical to harness the full potential of technology in their classrooms. In the 21st century, rapidly evolving educational realms, the integration of Information and Communication Technology (ICT) has become imperative for effective teaching and learning experiences (Budiarto et al, 2024). In the context of Biology Education, teachers' proficiency in ICT plays a pivotal role in enhancing pedagogical approaches and ultimately impacting students' learning outcomes.

The 21st century has experienced the adoption of ICT in teaching and learning and has become the standard for improving teaching and learning delivery (Zivave et al., 2025). There is a wealth of ICT tools and resources that may significantly transform teaching practices or, at least, bypass the traditional techniques when applied to disciplines such as Biology. To get the greatest benefits out of the ICT in education, there is the need to determine the ICT competency of the teachers because this aspect defines the teaching competency (LazaroCantabrana, et al., 2019). ICT is most significant part of the current academic system in imparting knowledge to students. The design recommendations for Biology teachers are the teachers should have proficient ICT skills to facilitate the delivery of content and to capture the attention of the students.

The integration of ICT in biology education provides opportunities for interactive learning, visualizations and simulations that can enhance teachers' understanding of complex biological concepts (Putri, et al., 2024). Consequently, Biology teachers need to possess a certain level of ICT Competency to effectively leverage these resources. The integration of ICT in Biology education has transformed teaching methodologies, requiring educators to be proficient and competent in utilising digital tools. ICT competency encompasses the ability to effectively use various digital technologies and applications for communication, information retrieval, and content creation. In the context of education, it involves the skill to integrate technology seamlessly into teaching practices, thereby enriching the learning environment (Sabri, et al., 2024).

ICT competence encompasses the ability of Biology educators to effectively display knowledge of digital tools and technologies to facilitate instruction and create engaging learning environments. A teacher's level of ICT competence directly influences pedagogical choices, this enables the teachers to leverage technology for diverse instructional strategies Khong, et al., (2023). For instance, incorporating multimedia resources, interactive simulations and virtual laboratory can foster a deeper understanding of complex biological concepts (Mariati, 2024). Biology teachers with high levels of ICT competence possess the knowledge and skills necessary to leverage digital resources to enhance their instructional practices. This includes the ability to create engaging multimedia content, utilise interactive learning platforms, and effectively navigate accurate online educational resources.

Competence in ICT usage empowers Biology teachers to customize learning experiences, catering to diverse learning styles and individual student needs (Sabri et al., 2024). ICT integration in pedagogy has been shown to increase student engagement and participation. Interactive digital tools simulations, and multimedia resources provide dynamic learning experiences, capturing students' attention and fostering a deeper understanding of complex concepts (Abubakar, et al., 2024). Furthermore, ICT facilitates collaborative learning, enabling students to work together on projects, share ideas, and engage in discussions beyond the confines of the physical classroom (Owens & Hite, 2022).

One of the greatest strengths of ICT in Biology education lies in its capacity to support personalised learning, adaptive learning platforms and intelligent tutoring systems can analyse individual student data to tailor instruction, providing targeted interventions and challenges based on each student's progress and abilities (Marouf et al., 2024). This adaptive approach allows for a more personalised and differentiated learning experience, optimizing outcomes for learners with diverse needs. ICT tools can be harnessed to promote critical thinking and problem-solving skills among students. Engaging with digital resources requires analytical thinking, assessment of information sources, and the ability to synthesize knowledge (Huang, et al., 2017). Moreover, technology-enabled learning environments often incorporate interactive simulations and virtual labs, providing opportunities for hands-on experimentation and inquiry-based learning (Tsakeni, 2022).

Pedagogical approaches encompass the strategies, methods, techniques and approaches that teachers employ to facilitate learning and foster student development. These practices are deeply rooted in educational theory and are influenced by a combination of factors including teaching philosophy, subject matter expertise, student needs, and instructional context. Effective pedagogical approaches not only transmit knowledge but also promote critical thinking, creativity, collaboration, and problem-solving skills among students (Bhuttah, et al., 2024). One crucial aspect of pedagogical approaches is the instructional design. Teachers must carefully plan and organize their lessons to ensure that learning objectives are met and that subject matter content is presented clearly and engagingly. This involves breaking down complex concepts into manageable chunks, sequencing activities to scaffold learning, and incorporating a variety of instructional materials and resources to cater for diverse learning styles and preferences (Swargiary, 2024).

Furthermore, effective pedagogical approaches emphasise active student engagement. Rather than passively receiving information, students are encouraged to participate actively in the learning process through discussions, group work, hands-on activities, and experiential learning opportunities. This active engagement not only enhances comprehension but also promotes higher-order thinking skills such as analysis, synthesis, and evaluation. In addition to instructional design and student engagement, assessment is another key component of pedagogical approaches (Asiyai & Asiyai, 2018). A deep-rooted ICT competence can be a cornerstone of effective pedagogy.

When educators are equipped with appropriate skills to leverage digital tools and resources, they can create dynamic, engaging learning environments that cater the diverse needs of students. By fostering critical thinking, facilitating personalised learning journeys, and enhancing student engagement, ICT contributes significantly to the evolution of education, preparing students for success in an increasingly digital world. However, it is crucial to address challenges and promote equitable access to technology to ensure that all students have the opportunity to benefit from the transformative potential of ICT in education. In the digital age, ICT competence is a cornerstone of effective pedagogy (Asiyai & Asiyai, 2018).

The proficiency of biology teachers in utilising ICT tools is a critical factor in determining the extent to which technology is integrated into their teaching practices (Hidayat, et al., 2024). Biology teachers are expected to have a solid grasp of fundamental ICT tools, including word processors, presentation software, and internet navigation (Smith & Doe, 2017). These skills are fundamental for creating instructional materials and accessing online resources. Integration of visual aids, animations, and multimedia resources can significantly enhance biology instruction (Mersha, 2024). Biology teachers' ICT competences are integral to the effective integration of technology in education. As the educational landscape continues to evolve, Biology teachers must remain proactive in developing and enhancing their ICT skills. Targeted professional development, collaborative initiatives, and a proactive approach towards emerging technologies are key to ensuring that Biology educators are equipped to provide high-quality technologically enriched learning experiences. Biology teachers with higher ICT competence levels tend to employ more diverse and innovative teaching strategies (Chen & Cowie, 2018). They effectively leverage digital resources, simulations, and multimedia to create interactive and engaging learning experiences for students.

Biology teachers with advanced ICT skills can implement personalised learning approaches, tailoring instruction to individual student needs Makuru, & Jita, (2022). Technology enables adaptive assessments, differentiated instruction, and opportunities for self-paced learning. ICT proficiency empowers Biology teachers to utilise data analytics tools for formative assessment and progress monitoring (Ng et al., 2018). This allows for timely feedback and targeted interventions to support student learning. Proficient use of tools like interactive simulations and virtual laboratory allows for dynamic and engaging learning experiences (Kolil & Achuthan, 2024). Competence in statistical analysis tools enables teachers to effectively interpret and convey complex biological data to students. Virtual laboratory provide opportunities for hands-on experimentation in a digital environment (Bebell & Kay, 2019).

The ICT Competence Framework for Teachers (ICT-CFT) developed by (United Nations Educational, Scientific and Cultural Organization, UNESCO, 2011) is a comprehensive guide designed to support educators in the effective integration of information and communication technology (ICT) into teaching activities. This framework plays a critical role in enhancing teachers' ICT skills, enabling them to utilise digital tools to improve teaching outcomes (UNESCO, 2011). This framework emerged from the understanding that traditional literacy, which focuses primarily on reading, writing and drawing in a single language, is inadequate in the context of today's technology-driven world. The ICT-CFT addresses the need for a broader view of literacy that incorporates various digital and multimedia literacies. It assists educators in navigating the complexities of modern Biology education by focusing on several key areas. One of the fundamental components of the ICT-CFT is to understand the role of ICT in Biology education. This highlights the necessity of ICT-CFT for teachers to comprehend the broader implications of technology within the educational context. It encompasses the potential of ICT to support educational goals, such as enhancing student engagement, promoting equity, and preparing students for a digital society (UNESCO, 2011). Teachers are encouraged to remain informed about technological advancements and to reflect on the ethical and social implications of technology use. Also, the ICT-CFT involves integrating ICT into curriculum and assessment. It provides guidance on incorporating digital tools and resources into lesson plans and assessment methods. Effective integration of ICT can enrich content delivery and create a more interactive learning experience. The framework advises teachers to align the use of technology with curriculum objectives and design assessments that reflect the digital skills students require through pedagogical approaches (UNESCO, 2011).

Pedagogical approaches represent another critical aspect of the ICT-CFT. It emphasises adopting instructional strategies that utilise technology to foster student-centered and inquiry-based learning. This includes using ICT to support collaborative learning, personalised education, and the development of critical thinking skills. The framework encourages teachers to adopt pedagogical approaches that will cater to the diverse needs of the students (UNESCO, 2011). Furthermore, technical skills underscore the importance of teachers being proficient with a range of digital tools, from basic software to advanced educational technologies. Continuous skill development is essential to keep pace with technological advances and effectively support student learning (UNESCO, 2011). The organization and administration aspect focuses on using ICT to manage educational resources and improve communication within the educational environment. Teachers are encouraged to utilise digital tools for organizing teaching materials, communicating with colleagues and students, and engaging in professional networks. Effective use of ICT extends beyond the classroom, supporting the broader educational ecosystem (UNESCO, 2011). The framework further highlights the importance of professional learning. Ongoing development is crucial for teachers to maintain and enhance ICT skills. The framework promotes involvement in professional learning opportunities, such as workshops and online courses, and encourages the sharing of knowledge and best practices among educators (UNESCO, 2011). Relating the ICT Competence Framework for Teachers to Biology education, the framework's principles are highly relevant. Digital tools and resources play a significant role in teaching complex biological concepts and supporting inquiry-based learning. For instance, virtual labs and simulations enable students to explore biological processes interactively, while data analysis software allows for the examination of genetic data and the development of critical scientific skills.

Biology teachers can apply the ICT-CFT by integrating digital microscopes, simulation software, and other technological resources into lesson delivery, thereby enhancing student engagement and accommodating diverse learning needs. The ICT-CFT focuses on pedagogical strategies to encourage Biology educators to use ICT to facilitate collaborative projects and personalised learning experiences (UNESCO, 2011). In terms of professional development, the ICT-CFT guides Biology teachers to pursue ongoing training and stay updated with the latest technological advancements. This includes participating in professional learning communities where teachers can exchange ideas and strategies for integrating ICT into Biology teaching. It also addresses the ethical use of technology, ensuring that teachers consider issues such as data privacy and digital equity (UNESCO, 2011). The promotion of the ICT-CFT of pedagogical strategies further broadens the need to possess relevant knowledge.

To promote effective technology integration in the teaching and learning process, Mishra and Koehler (2006) developed the TPCK framework. Technological Pedagogical Content Knowledge (TPCK) was introduced to the educational research field as a theoretical framework for understanding the required teachers' knowledge for effective technology integration. The TPCK framework acronym was renamed TPACK (pronounced "tee-pack") for the purpose of making it easier to remember and to form a more integrated whole for the three kinds of knowledge addressed: technology, pedagogy, and content (Thompson & Mishra, 2007–2008). The TPACK framework builds on Shulman's construct of Pedagogical Content Knowledge (PCK) to include technology knowledge as situated within the content and pedagogical knowledge.

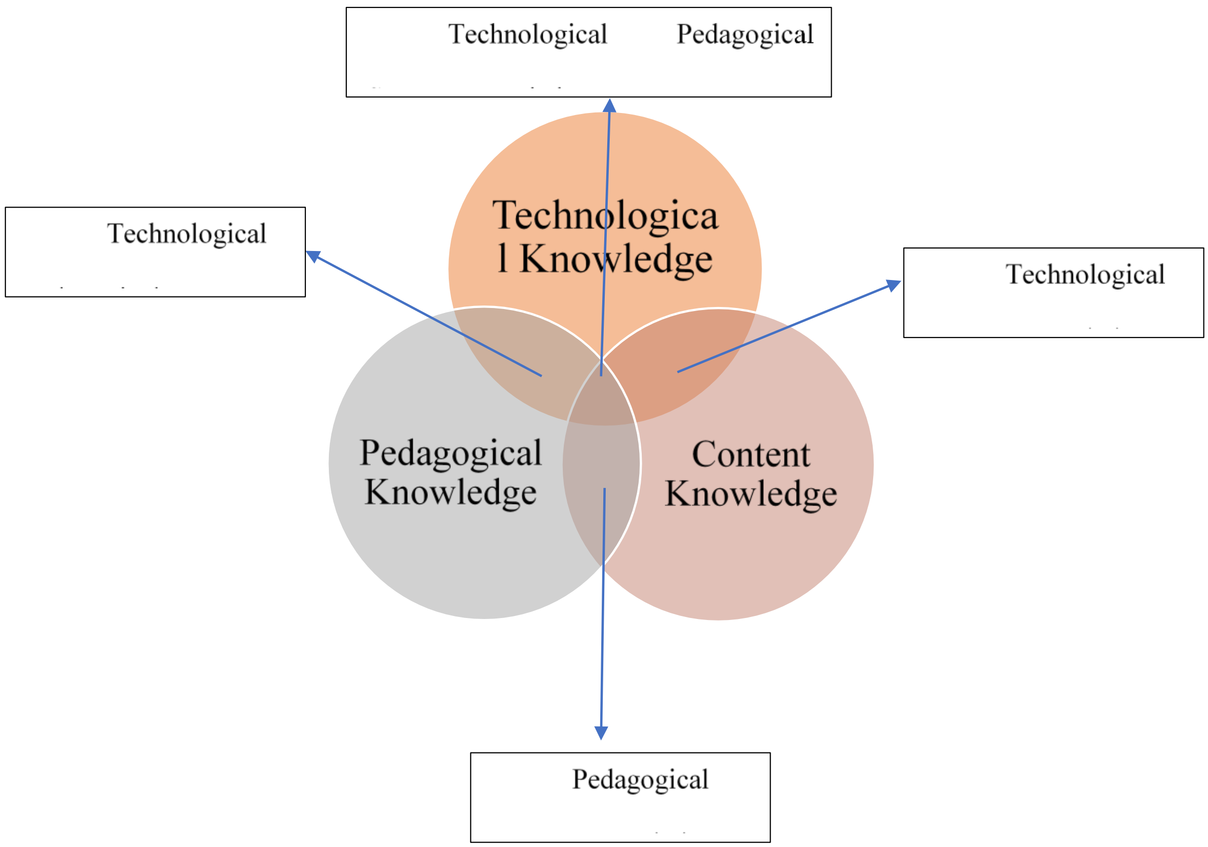

Figure 1: Technological Pedagogical and Content Knowledge Framework (TPACK)
Source: Mishra and Koehler (2006)

A precursor to the TPACK idea was a brief mention of the triad of content theory (as opposed to pedagogy), and technology in Mishra and Koehler (2007) though within the context of educational software design. The relationships between technology, content, and pedagogy were established (Keating & Evans, 2001; Pierson, et al., 2001; Zhao & Frank, 2003).

TPACK is a framework that introduces the relationships and complexities between the three basic components of knowledge: technology, pedagogy, and content (Koehler & Mishra, 2008; Mishra

& Koehler, 2006). At the intersection of these three knowledge is an intuitive understanding of teaching content with appropriate pedagogical methods and technologies. Seven components (see Figure 1) are included in the TPACK framework. They are defined as follows: Technology knowledge (TK): Technology knowledge refers to having an understanding of different types of technology, from simple tools like pencil and paper to more complex digital tools like the internet, video, interactive whiteboards, and various software programmes. Content knowledge (CK): Content knowledge is about fully understanding the subject that needs to be taught or learned. Teachers need to be well-versed in the material they are teaching and aware of how knowledge differs from one subject to another.

Pedagogical knowledge (PK): Pedagogical knowledge is about knowing how to teach effectively. It covers skills like managing a classroom, assessing students, developing lesson plans, and fostering student learning. Pedagogical content knowledge (PCK): Pedagogical content knowledge is about knowing how to teach a particular subject in the best way possible (Shulman, 1986). Pedagogical content knowledge differs from one subject to another because it merges understanding of the material with effective teaching methods to enhance how the subject is taught. Technological content knowledge (TCK): Technological content knowledge is the awareness of how technology can provide new ways to present specific subject matter. It emphasises that teachers recognize how using certain technologies can transform how students engage with and grasp concepts within a particular field.

Technological pedagogical knowledge (TPK): Technological pedagogical knowledge is about knowing how to incorporate various technologies into teaching and appreciating how these tools can change the way educators deliver lessons. Technological pedagogical content knowledge (TPACK): Technological pedagogical content knowledge (TPACK) is the essential understanding teachers need to blend technology with their teaching across various subjects. It requires a clear grasp of how content, teaching methods, and technology work together, allowing educators to create effective lessons using the right approaches and tools. The framework emphasises the importance of designing and assessing teachers' knowledge aimed at enhancing students learning across different subjects (Chai et al., 2013). TPACK serves as a valuable framework for understanding the knowledge teachers need to effectively integrate technology into their teaching and how they can cultivate that knowledge. Utilizing TPACK to assess teaching knowledge could significantly influence the training and professional development opportunities created for educators.

The outcomes of this study highlight the vigorous role of ICT competence and skill levels in shaping how Biology teachers deliver instruction in secondary schools across North-Central Nigeria. Drawing from the Multiliteracies Theory, the ICT Competency Framework for Teachers (ICT-CFT), and the Technological Pedagogical Content Knowledge (TPACK) model, the study highlights the need for teachers to not only develop technical proficiency but also effectively incorporate digital tools into their pedagogical practices. The Multiliteracies Theory stresses the importance of adapting to diverse technological and cultural landscapes to ensure instructional methods remain relevant in a digitally evolving world. Likewise, the ICT-CFT framework advocates for continuous professional growth, enabling teachers to integrate ICT in ways that enhance student engagement and create interactive learning experiences. Furthermore, the TPACK model reinforces the need for a well-rounded understanding of content, pedagogy, and technology to improve lesson effectiveness and student learning outcomes.

Based on these theoretical perspectives, the study highlights the importance of structured training programmes designed to strengthen ICT competence and skills among Biology teachers, especially in rural areas with limited access to digital resources. The findings suggest that targeted professional development, gender-responsive training, and equitable access to ICT tools can help close existing gaps in technology adoption. Through the use of digital simulations, virtual laboratories, and collaborative online platforms, teachers can enhance instructional quality and create more engaging Biology lessons. The study advocates for policy measures that integrate ICT competence into teacher training programmes while promoting ethical digital practices in education. Ultimately, equipping Biology teachers with essential ICT skills will not only enhance their instructional methods but also contribute to a more inclusive and technology-driven learning environment, leading to improved student outcomes.

The capacity of teachers to use information and communication technology (ICT) in Nigerian secondary schools is a focal point for enhancing education quality. ICT proficiency in teaching enables better engagement and modernizes instructional methods. This explores the impact of school ownership, specifically public secondary schools, on the ICT competence and competency skill levels among teachers in North-Central, Nigeria. Ownership status often dictates the resources available for ICT tools and training, shaping teachers' proficiency and comfort with technology in education (Ali, 2024).

Teachers' ICT skills have become essential for fostering a digital-savvy generation, (net or connected generation) making ICT competence an integral component of modern education (Xu et al., (2025). ICT literate teachers can enhance student learning outcomes by making lessons more interactive, engaging, and effective through digital tools and resources, developing teachers' ICT skills is crucial for both current instructional needs and students' future careers in a technology-driven world (Irasuti & Bachtiar, 2024).

The critical factor impacting ICT competence among teachers in Nigeria's public secondary schools often faces severe funding limitations, which affects both the availability of ICT resources and access to professional development (Henseke, et al., 2021; Mohammed, et al., 2024). Unlike private schools, which have relatively flexible budgets allowing for the procurement of ICT resources, public schools often operate on restricted funding that limits technology updates and professional ICT training opportunities. The lack of regular access to ICT resources can hinder teachers' ability to become proficient with essential technology tools, impacting their teaching effectiveness and the overall quality of education provided (Akram et al., 2022).

Professional development plays an essential role in enhancing ICT competence among teachers; however, public school teachers often have fewer opportunities for ICT-focused training due to budgetary and logistical constraints. The studies show that ongoing professional development is crucial for teachers to acquire and sustain ICT skills, which is particularly important in a rapidly evolving digital landscape (Ottestad, et al., 2014). In many public Secondary schools, ICT-related training is limited, which creates challenges for teachers in implementing technology effectively in their lessons. According to Mumtaz, (2022), teachers in public schools who lack regular training opportunities are less confident in using digital tools, resulting in a reduced likelihood of adopting ICT-enhanced teaching methods. By prioritizing professional development specifically targeted at ICT skills, public Secondary schools could foster better digital competency and bridge the gap in ICT skill levels between public and private Secondary school teachers.

Infrastructure limitations remain a significant barrier to ICT competence in Nigerian public secondary schools. These schools frequently face issues such as inadequate computer laboratory, unreliable internet connectivity, and outdated equipment, all of which constrain teachers' ability to engage with technology regularly (Maphosa, 2021). The accessibility of ICT resources is directly linked to teachers' ability to build digital skills, as a lack of hands-on practice can diminish their ability to implement technology effectively in the classroom (Forde, & Obrien, 2022). Public Secondary school teachers often lack the opportunity to familiarize themselves with digital tools and software due to limited infrastructure, which can undermine both their ICT proficiency and their ability to provide students with a technology-rich educational experience (Cupido, 2022).

Teachers' attitudes toward ICT integration are influenced by resource availability, support structures, and exposure to technology. Public school teachers frequently exhibit apprehension or reluctance regarding ICT adoption, often due to insufficient resources, limited training, and inadequate technical support (Lawrence, & Tar, 2018). Research indicates that teachers who lack confidence in their ICT skills, due to limited experience or exposure, may be more resistant to integrating technology into their teaching practices (Spangenberg, & De Freitas, 2019). These attitudes are commonly observed in under-resourced public schools, where teachers may feel overwhelmed by the challenges associated with technology integration without adequate support. Addressing this issue through targeted policies and increased access to resources can foster a more positive attitude toward ICT use among public Secondary school teachers.

Administrative and policy support is crucial for advancing ICT competence in Nigeria's public Secondary schools. Although private schools often have policies that prioritize ICT development, public schools face systemic challenges, including limited funding and a lack of targeted ICT policies (Barakabitze, et al., 2019). Effective leadership from school administrators is essential to encourage ICT integration by implementing policies that prioritize resource allocation and continuous teacher training (Barakabitze, et al., 2019). As emphasised by research, administrative support not only boosts ICT adoption but also ensures that teachers receive ongoing professional development in digital literacy (Falloon, 2020). Public schools would benefit from policy reforms that allocate dedicated resources for ICT and provide clear frameworks for supporting teachers in developing the skills needed to leverage technology effectively in education.

The development of ICT competence among teachers in Nigerian public secondary schools is strongly affected by resource and funding limitations, restricted professional development opportunities, and inadequate infrastructure. These challenges create disparities among public Secondary school teachers in ICT proficiency. Public schools require focused interventions to address the specific limitations they face. Policy reforms, increased investment in ICT infrastructure, and accessible training programmes are essential to empower public Secondary school teachers in Nigeria with the skills and confidence needed to integrate technology effectively. Research suggested exploring practical strategies for enhancing ICT support in public Secondary schools to ensure that all educators are prepared to deliver high-quality, technology-driven education in Nigeria.

The use of (ICT) in education has significantly transformed teaching practices across various disciplines, including biology (Natarajan, et al., 2021). This literature review explores the evolving landscape of ICT utilisation in teaching biology concepts, examining its impact on pedagogy, student engagement, and learning outcomes. Advancements in digital visualization tools have revolutionized the way biology concepts are presented in the classroom. Virtual labs, simulations, and interactive models offer students the opportunity to explore biological phenomena in a controlled and dynamic environment (Aladesusi, et al., 2022). Studies suggest that these tools enhance students' conceptual understanding and promote a deeper engagement with biological processes (Adam, et al., 2024).

The use of digital visualization tools in biology instruction has revolutionized the traditional methods of teaching by providing dynamic and interactive learning experiences (Oka, 2021). This section delves deeper into the impact of digital visualization tools, examining specific examples and the pedagogical benefits they offer in the context of biology education. Virtual labs and simulations are powerful tools that immerse students in realistic biological scenarios, allowing them to conduct experiments and observe outcomes in a virtual environment. Platforms like BioDigital Human, Labster, and PhET Interactive Simulations offer a range of interactive simulations covering topics from cellular biology to ecology (Gulzoda & Feruza, 2024). These tools enable students to engage in hands-on learning experiences without the constraints of physical laboratories, fostering experimentation and exploration.

Digital visualization tools provide intricate 3D models of biological structures, allowing students to explore the complexities of organisms at a molecular level. Tools such as Visible Body and BioMan Bio offer detailed visualizations of biological systems, enhancing spatial understanding and conceptualization (Reyes, et al., 2024). These interactive models enable students to manipulate structures, zoom in on specific components, and gain a deeper insight into the intricacies of biological concepts. Multimedia presentations and animations play a crucial role in simplifying complex biological processes. Platforms like BioMan Bio feature interactive animations that elucidate cellular processes, DNA replication, and other fundamental concepts (Jenkinson, 2018). By visualizing dynamic processes through animations, students can grasp the temporal aspects of biological events, enhancing their comprehension and retention of information.

Adaptive learning platforms leverage digital tools to tailor instruction to individual student needs. These platforms assess students' progress and adapt the content based on their performance, providing targeted support where needed. Tools like Smart Sparrow and McGraw-Hill Connect use adaptive learning techniques to personalize the learning journey, ensuring that students receive content at an appropriate pace and difficulty level (Mtebe & Raphael, 2018). This adaptive approach enhances engagement and caters to diverse learning styles within a biology classroom. The integration of Virtual Reality (VR) and Augmented Reality (AR) technologies takes digital visualization to the next level. VR immerses students in virtual environments where they can explore biological structures and processes in a more immersive manner (Pramanik, 2024). AR overlays digital information onto the physical world, allowing students to interact with 3D models superimposed on their surroundings. These technologies provide a sense of presence and enhance spatial understanding, contributing to a more holistic learning experience (Adeghe et al., 2024). The use of digital visualization tools in biology instruction offers several benefits, including increased engagement, enhanced conceptual understanding, and accessibility to diverse learning styles. As technology continues to advance, future directions in this field may include the development of more sophisticated VR and AR applications, increased interactivity in simulations, and a focus on fostering collaboration and communication through these tools. The incorporation of digital visualization tools in biology instruction transforms traditional teaching methods, providing students with immersive and interactive learning experiences (Fitrianto & Saif, 2024). From virtual labs to VR applications, these tools contribute to a more dynamic and effective biology education, preparing students for a deeper understanding of the biological sciences in the digital age. (Byukusenge et al., 2022).

The proliferation of online resources and educational platforms has expanded access to a wealth of biological information. Platforms like Khan Academy, BioMan Bio, and others provide students with interactive lessons, quizzes, and multimedia resources, catering to diverse learning styles (Bekimovna, et al., 2024). Research indicates that incorporating such platforms into biology instruction can enhance student motivation and self-directed learning (Mtebe & Raphael, 2018). The emergence of Virtual Reality (VR) and Augmented Reality (AR) technologies has introduced new dimensions to biology education. VR allows students to explore complex biological structures and processes in immersive environments, fostering a sense of presence and spatial understanding (Pramanik, 2024). AR overlays digital information onto the real world, enabling students to interact with biological concepts in their physical surroundings. Research suggests that these technologies enhance spatial cognition and contribute to a more holistic understanding of biological structures (Byukusenge et al., 2022).

ICT facilitates collaborative learning experiences in biology education. Online platforms and communication tools enable students to engage in virtual discussions, share resources, and collaborate on projects (Zhou, & Lewis, 2021). Collaborative learning enhances students' social interaction and communication skills while fostering a sense of community in the study of biology concepts. While the utilisation of ICT in teaching biology concepts offers numerous benefits, challenges exist. Issues related to access to technology, teacher training, and the need for ongoing support are common concerns (Makuru, 2020).

Additionally, there is a need for research to assess the long-term impact of ICT integration on students' retention of biological knowledge and its application in real-world contexts. The study demonstrates a growing recognition of the potential of ICT in enhancing the teaching and learning of biology concepts. From digital visualization tools to online platforms and emerging technologies like VR and AR, educators have a diverse array of tools to engage students and promote deeper understanding. As technology continues to advance, further research is essential to explore best practices, address challenges, and ensure that ICT integration in biology education remains effective, inclusive, and aligned with the evolving needs of students and educators.

The use of ICT in biology education can be seen as a tool to support these approaches. For example, digital tools such as virtual labs, online databases, and interactive simulations can be used to provide students with hands-on experiences and real-time data analysis (Makinde, & Oyeniyi, 2024), these tools can also be used to facilitate collaborative learning, where students can work together to solve problems and conduct experiments. However, the successful integration of ICT in biology education is not without its challenges. These challenges include the need for adequate training for teachers, the availability of reliable and accessible digital tools, and the need for changes in pedagogical approaches to accommodate the use of ICT (Opeyemi, et al., 2019). Despite these challenges, the benefits of ICT in biology education are significant. It can enhance students' understanding of biological concepts, improve their problem-solving skills, and prepare them for the use of technology in their future careers. The utilisation of ICT in teaching Biology concepts is a promising approach to enhance the teaching learning process in Biology education (Farhana, et al., 2024). However, it requires careful planning, investment, and ongoing support to ensure its successful implementation.

Technology is rapidly being integrated into education across the world, many secondary school Biology teachers in North-Central Nigeria are still not effectively using Information and Communication Technology (ICT) in their classrooms (Badmus, 2023). Even though national education policies highlight the importance of ICT skills for teachers, many Biology educators lack the competence to apply these tools in their teaching. As a result, they find it difficult to move beyond basic ICT use to meaningful classroom applications that could make lessons more engaging, practical, and aligned with current educational standards. This limits students' participation, understanding, and interest in Biology, ultimately affecting their academic performance and preparedness for a technology-driven future.

The situation is more challenging in North-Central Nigeria due to a combination of rural and urban school settings, limited infrastructure, and unequal access to digital resources (Olanrewaju et al., 2021). While existing research has addressed general ICT access and teachers' attitudes, there is little evidence on how Biology teachers specifically use ICT to support their teaching methods. Effective ICT integration in science education requires more than basic digital skills; it demands the ability to use tools like simulations, animations, and digital laboratory to enhance inquiry-based and student-centered learning. This specific skillset referred to as pedagogical ICT competence, has not been adequately studied among Biology teachers in North-Central, Nigeria (Farhana et al., 2024).

If this issue remains unaddressed, students will continue to experience outdated teaching methods that hinder understanding and reduce motivation to pursue science careers. Teachers may also continue relying on lecture-based methods, failing to meet the goals of current education reforms that call for more interactive and practical learning environments.

Therefore, this study is needed to investigate school ownership and school location as predictors of Biology teacher's ICT competence on pedagogical approaches in North-central, Nigeria. The key gap to be filled is the lack of research that connects ICT competence with subject-specific, pedagogical practices in Biology. The findings will help guide teacher training, educational policy, and school support systems toward improving science teaching and student outcomes.

Purpose of the Study

The main purpose of the study was to assessed the possibility of school ownership and school location as predictors of Biology teachers' ICT competence on pedagogical approaches in North-Central, Nigeria. Specifically, the study aimed to;

1. find out the pedagogical approaches employed by secondary school Biology teachers in North-Central, Nigeria;
2. explored possible differences in the pedagogical approaches employed by secondary school Biology teachers in North-Central, Nigeria based on school ownership; and
3. Analysed the influence of school location on the pedagogical approaches employed by secondary school Biology teachers in North -Central, Nigeria.

Research Question

1. What is the pedagogical approaches employed by secondary school Biology teachers in North-Central, Nigeria?

Research Hypotheses

H01: There is no significant difference in the pedagogical approaches adopted by Biology teachers in private and public secondary schools in North Central, Nigeria;

H02: There is no significant difference in the pedagogical approaches adopted by Biology teachers in the urban and non-urban secondary schools in North Central, Nigeria.

Methodology

This study employed descriptive research of the cross-sectional survey type. The study describes events as they appear without any manipulation. It also collected data that were used to answer a wide range of what, when, and how questions about a particular population or group. The survey method involved the use of a standardised and validated questionnaire to collect data about respondents and their preferences, thoughts, and behaviours systematically. The study collected data that was used to answer the research questions. The population for this study consisted of all senior secondary school Biology teachers in North-Central, Nigeria. The target population for the study was all public senior secondary school Biology teachers across the six states and the FCT (Federal Capital Tertiary) in North-Central, Nigeria which is 1929 as shown in Table 1. Benue was exempted due to the insecurity, and Herder-Fulani clash and it was difficult to reach out to a research assistant in the state.

Table 1:
Distribution of Respondents and Sample Size by Percentage Representation

State	Population	% Representative	Sample
FCT	240	12.44	87
Kwara	566	29.34	204
Plateau	235	12.18	85
Niger	300	15.55	108
Nasarawa	425	22.03	153
Kogi	163	8.45	59
Total	**1929**	**100**	**696**

Source: Teaching Service Commissions of each Covered States, 2024.

The sample size for this study was determined from the total population of senior secondary school Biology teachers in North-Central, Nigeria as shown in Table 1. A multi-stage sampling procedure was employed for this study. Random sampling technique was employed to select schools based on ownership (Federal and State), and was also adopted for the selection of Biology teachers that participated in this study while stratified random sampling was employed to select teachers based on academic qualification. The academic qualification of Biology teachers in North-Central, Nigeria was categorised into Qualified, Moderately Qualified, and Unqualified. The Qualified Biology teachers are those with B.Sc. Ed., B.Ed., and B.Sc. with PGDE, HND with PGDE, M.Sc. Ed, M.Ed., and Ph.D. in Biology. The Moderately Qualified are those Biology teachers with NCE, while Unqualified are those with HND, B.Sc., and M.Sc. in Biology in North-Central, Nigeria.
Finally, proportional sampling was used to determine the sample representation of Biology teachers in each of the six states and the FCT. Based on Cohen, et al., (2018), a population of 1929 recommends 696 at a 95% confidence level, hence the sam**ple** size for this study was **696**. The research instrument that was used for this study was a researcher-designed questionnaire titled school ownership and school location as predictors of Biology teachers ICT competence on pedagogical approaches questionnaire. The questionnaire was made up of two sections: Section a comprised information on respondents' demography, which includes gender (male or female), names of schools, school ownership, School location, and academic qualification while Section B is sub-divided into two segments to cater for the research questions, which included 10 items in each of the segments. The response mode for all the items in each of the segments was a four-point Likert Scale type. Segment 1: ICT literacy level of Biology teachers in Secondary Schools in North-Central, Nigeria. Highly Literacy (HL); Moderately Literacy (ML); Fairly Literacy (FL); Not Literacy (NL), and Segment 2: Pedagogical Approaches Adopted by Secondary School Biology Teachers in North-Central, Nigeria. Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD).
The instrument for this study was validated by the researcher's supervisor and three other lecturers in the Department of Science Education, Al-Hikmah University, Ilorin. To determine the relevance and suitability of the instrument, they considered its language clarity to the respondents, content coverage in terms of adequacy and its relevance to the stated objectives. The comments, suggestions and corrections were used to produce a final draft of the instrument which was pilot-

tested to determine the reliability index. The research instrument was subjected to a reliability test to check for internal consistency. Cronbach Alpha reliability coefficient of 0.90 was obtained at a 0.05 level of significance. A reliability index of 0.71 for ICT competence level and 0.83 for pedagogical approaches for secondary school Biology teachers were obtained respectively.

Pilot Study

A pilot study was conducted prior to the commencement of the main investigation. The pilot exercise was carried out in secondary schools located in Oyo State, purposefully selected because it lies outside the study area of North-Central, Nigeria. This strategic decision was aimed at minimizing potential biases while testing the instrument among a demographically similar, yet independent, group of Biology teachers. Public secondary schools were included in the pilot sample, with selection criteria based on availability of qualified Biology teachers, and the readiness of school authorities to support the research activity. The researcher initiated the process by personally visiting the selected schools to meet with their principals. During these visits, a formal introduction of the study was provided along with an official request letter seeking approval to administer the instrument. The intent of the pilot test was clearly outlined, with an emphasis on its purely academic purpose and assurance that it was not an evaluative exercise.

Upon receiving approval, the researcher worked collaboratively with school administrators to agree on suitable dates and times that would not disrupt the schools' normal academic schedule, thereby facilitating a smooth administration process. Following the principals' approval, the researcher engaged directly with the participating Biology teachers. A brief orientation session was held to explain the purpose of the pilot study, highlighting the importance of their sincere participation and how their feedback would help improve the research instrument's quality. Participants were assured of the confidentiality of their responses and were encouraged to respond thoughtfully. Adequate time was provided to complete the questionnaire, and no form of pressure was applied, allowing teachers to reflect carefully on each item.

Fifty copies of the questionnaire were distributed among the selected Biology teachers across the participating schools. The instrument covered key areas including ICT competence levels and pedagogical approaches. The researcher was present throughout the process to offer necessary clarification and ensure that all respondents had a uniform understanding of the questions. Once all completed questionnaires were collected, a thorough review was carried out to confirm that responses were complete and logically consistent, ensuring data quality for subsequent analysis.

The researcher obtained a letter of introduction from the Head of the Department of Science Education, Al-Hikmah University, Ilorin, and proceeded to the selected secondary schools to present the introductory letter to request permission to conduct the study. The researcher employed the services of five research assistants, one in each State, to cover all the secondary schools under investigation while the researcher handled the overall supervision. Proper orientation on how to fill and administer the questionnaire was given to the research assistants. Copies of the introductory letter, as well as the consent form given to the research assistants.

With the help of research assistants, the researcher administered copies of the questionnaire to the Biology teachers in all the sampled schools. The teachers were allowed to respond to the instrument at their convenience. Hence, responses provided by the respondents were used for this research only and treated with utmost confidentiality. Responses collated were transformed into data in readiness for statistical analysis.

Descriptive and inferential statistics were used to analyse the responses obtained from the questionnaire. All the demographic information was analysed using simple percentages and frequency counts. All research questions were answered through mean and standard deviation. The t-test was used to test hypotheses 1 & 2. The Statistical Product and Service Solution (SPSS) version 25.0 was used to test all the formulated null hypotheses at the significance level of 0.05.

Results and Interpretations

Research Questions One

What are the pedagogical approaches adopted by secondary school Biology teachers in North-Central, Nigeria?

Table 2:
Pedagogical approaches adopted by secondary school Biology teachers in North-Central, Nigeria

SN	Items	Mean	St.D
1.	I frequently employ inquiry-based learning methods to engage students in exploring biological concepts.	1.78	0.76
2.	I integrate hands-on laboratory practical activities to provide students with experiential learning opportunities in biology.	1.77	0.61
3.	I incorporate technology-enhanced teaching methods, such as	1.58	0.62
4.	Multimedia presentations and online simulations, to supplement traditional instruction in biology.	1.82	0.65
5.	I employ differentiated instruction techniques to address the diverse learning needs and abilities of students in my biology classes.	1.69	0.67
6.	I encourage student-centers learning by facilitating discussions, debates, and projects that allow students to take ownership of their learning in biology.	1.75	0.68
7.	I incorporate interdisciplinary approaches by connecting biology concepts with other subjects such as chemistry, agricultural science, or mathematics.	1.71	0.63
8.	I regularly use formative assessment methods, such as quizzes, and peer evaluations, to monitor student progress and provide timely feedback in biology.	1.78	0.69

SN	Items	Mean	St.D
9.	I promote critical thinking skills by presenting students with authentic biological problems and challenges to solve.	1.67	0.64
10.	I create a supportive and inclusive learning environment in my biology classroom that values student contributions and fosters a sense of belonging.	1.71	0.65

The results in Table 2 present an overview of the pedagogical strategies employed by secondary school Biology teachers in North-Central Nigeria. The table ranks various teaching methods based on their mean scores, with lower scores reflecting less frequent usage of these approaches. The most commonly used strategy, with a mean score of 1.82, is the use of multimedia presentations and online simulations to complement traditional Biology lessons. This indicates that teachers are integrating digital tools to enhance student engagement and deepen their understanding of biological concepts. The second most frequently employed method, with a mean score of 1.78, is inquiry-based learning, suggesting that teachers actively engage students in exploring biological concepts through questioning and hands-on investigation. Formative assessment techniques, such as quizzes and peer evaluations, also rank highly with a mean score of 1.78, reflecting teachers' dedication to monitoring student progress and providing timely feedback.

Hands-on laboratory practical activities, which provide experiential learning opportunities, are another commonly utilized strategy, with a mean score of 1.77. Other strategies used by teachers include student-centered approaches such as discussions, debates, and projects (mean score of 1.75) and interdisciplinary teaching that connects Biology to subjects like chemistry and mathematics (mean score of 1.71). Teachers also emphasise creating a supportive and inclusive classroom environment (mean score of 1.71), where students feel encouraged to participate and contribute. On the other hand, strategies like differentiated instruction (mean score of 1.69) and promoting critical thinking through real-world biological problems (mean score of 1.67) are used less frequently. These lower scores suggest that these approaches might not be as commonly applied in the region's Biology classrooms.

Research Hypotheses

H01: There is no significant difference in pedagogical approaches adopted by secondary school Biology teachers in North Central, Nigeria based on school ownership

Table 3:

t-test of significant differences in pedagogical approaches adopted by secondary school

Ped & Sch. Own.	Mean	St.d	Std. Error	df.	t (Cal.)	Sig. (2 tailed)	Decision
Pedagogy	17.27	4.74	0.18	695	88.76	0.00	Rejected
School Ownership	1.19	0.39	0.01				

The results from Table 3 show the outcomes of a t-test aimed at determining whether there is a significant difference in the pedagogical approaches used by secondary school Biology teachers in North Central, Nigeria, based on school ownership. The mean for pedagogical approaches is 17.27, with a standard deviation of 4.74, while the mean for school ownership is 1.19, with a standard deviation of 0.39. The t-test yields a calculated t-value of 88.76 and a p-value of 0.00. Since the p-value is smaller than the significance level of 0.05, the null hypothesis (H07) is rejected. These results indicate that school ownership has a significant effect on the pedagogical methods employed by Biology teachers in the area. Consequently, the type of school whether public or private appears to play a role in shaping the teaching strategies used by Biology teachers in secondary schools in North Central Nigeria.

H02: There is no significant difference in pedagogical approaches adopted by secondary school Biology teachers in North Central, Nigeria based on school location.

Table 4:

t-test of significant differences in pedagogical approaches adopted by secondary school

Ped&Sch.Own.	Mean	St.D	Std. Error	df.	t (Cal.)	Sig. (2 tailed)	Decision
Pedagogy	17.27	4.74	0.18	695	88.98	0.00	Rejected
School Location	1.19	0.39	0.01				

The results in Table 4 present the outcome of a t-test aimed at examining whether there is a significant difference in the pedagogical approaches of Biology teachers in secondary schools in North Central, Nigeria, depending on the school location. The average score for pedagogical approaches is 17.27, with a standard deviation of 4.74, while the school location has a mean score of 1.19, with a standard deviation of 0.39. The t-test produced a calculated t-value of 88.98 and a p-value of 0.00. Since the p-value is less than the significance threshold of 0.05, the null hypothesis (H08) is rejected. These findings suggest that the location of the school, whether urban or rural, plays a significant role in shaping the pedagogical approaches employed by Biology teachers in secondary schools in North Central, Nigeria.

Conclusion

In conclusion, the study shows that Biology teachers in secondary schools across North-Central Nigeria adopt a range of teaching strategies, with the most prominent being multimedia presentations, online simulations, inquiry-based learning, formative assessments, and practical laboratory work all aimed at improving student participation and comprehension. In contrast, approaches like differentiated instruction and activities designed to develop critical thinking appear to be less common, highlighting areas where further capacity building is needed. The analysis also indicates that both the type of school and its location have a significant impact on the teaching methods employed, meaning that institutional structures and geographical settings shape instructional choices. These findings point to the importance of tailored interventions, particularly targeted ICT-focused training and resources, to ensure more equitable and innovative teaching practices across varied educational environments in the region.

Recommendation

Based on the findings, it is recommended that:

1. Targeted professional development programs be implemented to strengthen underutilized pedagogical approaches among Biology teachers.
2. ICT training initiatives be customized to address specific needs arising from differences in school ownership.
3. Context-sensitive teaching support be provided to bridge pedagogical gaps between urban and rural school locations.

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EXTENT OF UTILIZING BUSINESS EDUTAINMENT IN TERTIARY INSTITUTIONS IN RIVERS STATE AS SCALABLE EDUCATIONAL TECHNOLOGY SOLUTIONS FOR TEACHING LARGE CLASS

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Abstract

Integrating technological tools in enhancing teaching and learning in educational programmes has continued to attract attention in academic discourse. This is based on the fact that globally, students have become more opened to learning through technologies that enable multimedia content delivery for educational purposes. Consequently, with access to android smart technologies affordable for connecting to the internet, the researcher was curious to find out whether multimedia content such as business edutainment that are available and accessible through YouTube channels, Movies Appx and online documentaries are being utilized in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class of Business education students. To address this curiosity, three specific purposes translated into three research questions and three hypotheses guided the conduct of the study. Descriptive research design was adopted. The population for this study consisted of 122 Business education lecturers from the four tertiary institutions offering Business Education in Rivers State during the 2024/2025 academic session. The entire 122 Business education lecturers were used as the sample size because it was a manageable size and therefore a census study. Data collected through a validated structured questionnaire were analysed using mean and standard deviation to answer research questions raised. Analysis of Variance (ANOVA) was used to test the hypotheses formulated at 0.05 level of significance. The findings revealed that business edutainment accessed through YouTube channels, Movies Apps and online documentaries were to a low extent utilized by Business Education lecturers as scalable solution to teach large class business practices. The findings also revealed that

there is no significant difference in the extent to which business edutainment is being utilized by Business Education lecturers as scalable solutions to teach large class of business practices.
Keywords: *Edutainment, Business Edutainment, Utilization, EduTech Scalable Solution, Business Practices*

Introduction

The advancement in technological tools and their subsequent integration into the educational system for the purpose of enhancing teaching and learning has continued to provide educators with voyage of discoveries. Some of the discoveries made through results of valid experimentation have been eroded by new ones. For example, filmstrips utilization in promoting the dual coding of educational contents among learners, have been replaced by the use of variety of modern video tools. Video tools such as digital videos, video blogs, PowerPoint presentation, YouTube videos, MovieWatch and online documentaries now provide educators with scalable solutions through the use of user-generated content or online videos to support their students dual coding of educational content in multimedia formats.

Educational content in multimedia formats according to Ojo and Akhademe (2016) refers to the use of tools that enable multimedia content creation by simultaneously combining video, sound, graphic and animation in creating messages aimed at educating the audience. Hiran (2017) also noted that educational materials can be translated into multimedia content using combination of motionless or motion pictures, diagrams, graphs, illustration or animations with verbal narrations helps to reduce cognitive overload by empowering students to connect between different pieces of information leading to a more comprehensive understanding of the subject. Abdulkarim and Agburuga (2016) suggested some possible combinations of media when creating multimedia educational content to include but not limited to using motion picture plus audio narrative, or motionless pictures plus verbal narration; or diagrams, illustration plus verbal narration. Nevertheless, whatsoever the combination may be and its format, what matters to most educational stakeholders such as students, parent or guardian, and educators is its capability in enhancing learning and the attaining educational goals and objectives.

One possible scalable format of multimedia educational content with dual purposes capable of enhancing learning and the attainment of educational objectives across a large audience at the same time is Edutainment. According to Dore et al (2019), edutainment as a multimedia content is created through the incorporation of educational messages into a piece of entertaining motion pictures of value to learners especially as will enhance their knowledge acquisition and influence attitude or behavioural change. Shamimah (2017) noted that Edutainment provides students with motivational power to learn through observing motion pictures of the activities of actors accompanied with verbal narrations. Rosenthal and Folb (2021) noted some sources of edutainment to include telenovela, videos, YouTube channels or videos, documentaries (offline or online), acting books, simulations and online platforms. Borum (2021) also noted that Edutainment can be used to absorb students in a narrative capable of persuading them to learn from a storyline relating to any aspect of their career or personal life. Consequently, every edutainment that is related to specific trade or career can be utilized to teach certain aspects of the trade or career.

The utilization of any edutainment containing business lessons aimed at helping students to learn business procedures, ethics, policy, and/or evaluation is referred to as business edutainment. According to Guzairy et al (2018), business edutainment has to do with tailoring the content of motion films or videos to include messages transmitting business knowledge and processes of developing competencies. Similarly Barsoum et al (2021) posited that business edutainment has to do with entertainment piece of act containing knowledge of business processes and principles, hence educates the audience about business while entertaining them. Piotrowski and Meester (2018) reported that apart from helping students to acquire business knowledge and understand the procedures for developing certain cognitive and psychomotor business skills related to operations, business edutainment stir up the students' emotions and interest of undertaking commercial ventures. Inferring from the discourse so far, it can be concluded that business education lecturers can utilize any accessible online business edutainment sources to provide their large class of students with opportunity to develop business knowledge and procedures for developing requisite skills for their future business endeavours. Consequently, within the context of this study, the utilization of three common sources of business edutainment namely YouTube channels, MovieBox App and online documentaries by business education lecturers as a scalable solution to teaching large class size were assessed.

There are much user-generated content with business knowledge and processes on YouTube channel. According to Icha and Agwu (2015), YouTube channel offers users free video sharing and social networking sites where registered users create, share and watch videos both for educative and entertaining purposes. Ordu and Abdulkarim (2020) reported that dispersed business education students can be taught and guided to acquire knowledge and skills for business establishment by asking them to watch YouTube channel videos. Levit (2022) noted that to help majority of students having access to smart phones with YouTube channel download business edutainment content, educators of business courses must formulate questions to assist in discernment and critiquing content of the videos watched for the purpose of learning and entertainment.

Customized video apps for smart phones have now made it possible to reach the needs and demand of multiple viewers around the globe. One video app popular among user of android phones is MoviesBox app. It is designed to provide end-users with choice of movies from the 1980s till date. Many of these movies provide the audiences with impactful knowledge related to a particular subject or concept (Raymond, 2019). See (2018) noted that beyond traditional classrooms, videos downloaded from online applications cater for the learning preference of different learners, inspire curiosity, engage students in critical thinking, and simulate their thirst for knowledge. Inferring from the foregoing, the utilization of common video download app should provide most students with the opportunity to meet their learning needs at their own convenient time. Nevertheless, the business education lecturers have significant role to play in screening and selecting movies from time to time for students' referral when required.

There are also many business knowledge and procedures that have been documented over the years especially as it relates to successful entrepreneurs and business practices. Many of these documentaries are accessible online through different platforms. Patel (2019) noted that good online documentaries relating to the journey and success stories of entrepreneurs are mostly informative apart from being entertaining; watching them can make one come away smarter than before screening them. Daniel (2023) noted that documentaries are means of educating large number of recipients and appealing to their emotions to make the right choices in driving business innovation and business. Inferring from the foregoing, there is much expectation that the utilization of business edutainment by lecturers should help their students learn en masse and at their own pace. Another important feature of using the business edutainment from the three sources to be assessed in this study is that business education lecturers can always review new uploads and refer their students to access them for screening, hence a scalable educational technology solution for teaching and learning.

Extant studies exist on business edutainment utilization. Funch et al (2016) conducted an historical review of the use of educational films in school among educators or students to teach and learn business courses in Pennsylvania. The review revealed that although teachers and students are familiar with Videos, very few of these stakeholders care to select films with content relating to their programme for teaching and learning. Cox et al (2017) assessed the utilization of mini-series of edutainment in developing pharmacy preceptors; it was highly utilized to increase the confidence of the participants and was an honorable mention for the American Association of Colleges of Pharmacy Innovations in Teaching Award in 2015. Barsoum et al (2021) assessed the impact of business edutainment on adult business intention. The researchers concluded that the utilization of business edutainment impacted on the viewers' attitudes toward small scale business ownership intention as source of self-employment. Roslim et al (2021) investigated the use of movies for teaching and learning languages to stimulate students' interest towards self-actualisation in tertiary institutions. The results revealed that using video films helped students to develop interest in their career paths, develop oral presentation skills and increased their motivation to participate in stage drama therefore decreasing their anxiety and tension.

In another study, Huq (2023) assessed the use of 'Grand Café' documented film containing 6 episodes of aspiring immigrant woman entrepreneur named Sylvia who came from Mexico and with her friends embarked on adventure to start their own businesses in the United State while improving on their English language. The findings also revealed that the use of documented film enabled students developed financial literacy skills for small scale businesses and the consciousness to promote own businesses even in environments where they are coping to survive. Greeves and Oz (2024) conducted study to compare the views of students and instructors about the use of YouTube in higher institutions of learning. The results revealed similarities in the views of students and instructors with regards to the choice of YouTube channel based on the accuracy of information disseminated, the content creator's expertise, the length of the YouTube video records, and the style of content presented. The results also showed that respondents opined that there is poor understanding among students and instructors about the educational benefits of YouTube channel. A cursory look at the existing empirical works revealed that none was conducted to determine the extent of utilization business edutainment in tertiary institutions in Rivers State as a scalable solution for teaching large class, hence, the gap in existing literature that the present work filled.

Statement of the Problem

The ideal class size for theoretical and practical teaching and learning in business education was pegged at 30:50 respectively (National University Commission, Core Curriculum Minimum Academic Standard, NUC-CCMAS, 2022; National Commission for Colleges of Education, NCCE, 2020). However, a situation where a large class size has to be accommodated in most tertiary institutions offering business education in Rivers State in order to give more students opportunity to enroll for the programme, comes with attendant effects. The effects as visible in tertiary institutions in Rivers State include overcrowded lecture halls, no or limited attention to individual student, poor performance of practical work, adequate skills development and difficulty in assessment and feedbacks. Some of the remedies for addressing the challenges of large class size include the use of online platforms, the use of videos, automated grading system and virtual classroom. Of all these remedies, the cheapest that can be activated through the collective efforts of educators and their students without much formality is the use of online movies or video recordings in form of business edutainment from common sources such as YouTube, Movies App and Online documentaries. These sources can provide scalable business edutainment that can be reviewed, adjusted and utilized to complement lectures that meets the ever-increasing demand of a large class size. However, the researcher is not sure if this remedy is actually utilized in tertiary institutions in Rivers State to provide scalable educational technology solution for teaching large class size. This led to the need to assess the extent of utilizing business edutainment in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class

Purpose of the Study

The aim of this study was to investigate the extent of utilizing business edutainment in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class. Specifically, the study sought to:

1. Determine the extent to which business edutainment from YouTube channels are utilized in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class.
2. Determine the extent to which business edutainment from Movies Apps are utilized in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class.
3. Determine the extent to which business edutainment from online documentaries are utilized in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class.

Research Questions

The following research questions guided the study:

1. To what extent are business edutainment from YouTube channels utilized in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class?
2. To what extent are business edutainment from Movies apps utilized in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class?
3. To what extent are business edutainment into form of online documentaries utilized in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class?

Null Hypothesis

The following null hypothesis was tested at 0.05 level of significance:

Ho_1 There is no significant different between the extent to which business edutainment from YouTube, Movies Apps and in form of online documentations are in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class.

Methods

Descriptive survey research design was adopted for this study. The design was deemed appropriate since the researcher major concern was with describing the prevailing situations of the variable under study. This study was conducted in River State of Nigeria. The State is a host to four tertiary institutions offering Business Education programme at the undergraduate level. These are Rivers State University, University of Port-Harcourt, Ignatius Ajuru University of Education and Federal College of Education (Tech.), Omoku. The presence of these institutions made the area a good choice for the study.

The population for this study was made up of 122 Business education lecturere from four tertiary institutions in Rivers State. The tertiary institutions are Rivers State University - 31, University of Port-Harcourt - 12, Ignatius Ajuru University of Education – 19 and Federal College of Education

(Tech.), Omoku - 58. The entire population of 122 was used as the sample size of the study because it was a manageable size. Consequently, no sampling technique was used.

The researcher developed a structured questionnaire made up of three clusters for the purpose of data collection. The questionnaire was titled "Extent of Utilizing Business Edutainment in Tertiary Institutions for Teaching Large Class Questionnaire (EUBETITLQ)" and contains 18 items, six items assessing each of three objectives. The responses pattern was based on four points rating scales of Very High Extent (VHE -4points), High Extent (HE - 3points), Low Extent (LE - 2points) and Very Low Extent (VLE - 1point). The instrument was subjected to validation by two experts, one expert of Educational Measurement and Evaluation, and another of the department of Business Education all from Rivers State University, Port-Harcourt. The experts' comments and input were used to modify the instrument.

The reliability of the instrument was determined using Cronbach alpha method. A pilot test was conducted using the responses from 15 business education lecturers from Niger Delta University, Bayelsa State who were not be part of the study. The data collected were used to compute the reliability test using Statistical Package for Social Science version 24.0. The computation gave reliability indexes of 0.84, 0.86 and 0.87 for the three clusters. The instrument was personally administered by the researcher. It is important to note that all copies distributed were properly filled and retrieved. This gives a 100% rate of returns. Data collected for this study were analysed using mean and standard deviation to answer the research questions. Analysis of Variance (ANOVA) was used to test the null hypothesis at 0.05 level of significance. All computation were done using Statistical Package for Social Science (SPSS) version 24.0.

Results and Discussion

Research Question 1: To what extent are business edutainment from YouTube channels utilized in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class?

Table 1: Summary of Mean Scores on the Extent to which Business Edutainment from YouTube Channels are Utilized in Tertiary Institutions in Rivers State

S/No	YouTube Channel items	Mean	Std	Decision
1	I do refer students to YouTube channels demonstrating business edutainment on the processes involved in business decision making in different industries	2.38	1.02	LE
2	I make students to watch different YouTube channel showing business edutainment describing how entrepreneurs carryout their business practices	2.40	1.07	LE
3	I ask students to locate and watch YouTube movies showcasing business challenges and how they were handled	2.14	1.06	LE
4	I do refer my students to watch YouTube channel videos on business management processes	2.44	0.86	LE
5	I do provide my students with specific YouTube channels to enable them watch and learn different aspects of financial management	2.44	1.04	LE
6	I make students to watch YouTube channels capable of educating them on office ergonomics and management	2.48	1.08	LE
	Cluster mean and Standard deviation	2.38	1.02	LE

Table 1 shows that to a low extent business education lecturers do refer their students to business edutainment from YouTube channels demonstrating the process of business decision making, describing how entrepreneurs carryout their business practices, showcasing business challenges and how they were handled, showing business management processes, showing different aspects of financial management and educating on office ergonomics and management with mean scores of 2.38, 2.40, 2.14, 2.44, 2.44, 2.48 and standard deviation scores of 1.02, 1.07, 1.06, 0.86, 1.04, and 1.08 respectively. Similarly, when the cluster mean and standard deviation score of 2.38 and 1.02 are considered, it is concluded that to a low extent business edutainment from YouTube channels is being utilized by business education lecturers in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class

Research Question 2: To what extent are business edutainment from Movies apps utilized in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class?

Table 2: Summary of Mean Scores on the Extent to which Business Edutainment from Movies Apps are Utilized in Tertiary Institutions in Rivers State

S/No	Movies Apps items	Mean	Std	Decision
7	I ask my students to download business related movies showcasing business operations environments	2.39	1.01	LE
8	I do ask my students to watch certain business related movies that show different forms of businesses and their operations	2.10	0.68	LE
9	I do ask my students to watch certain business related movies with scenes showing departmentalisation of business organisation	2.28	1.16	LE
10	I do refer my students to download certain business related movies from apps in order to screen them and learn customer's relationship and management	2.21	0.99	LE
11	I do ask my students to watch certain business related movies downloaded from apps showing how capital are raised for starting own business.	2.19	0.98	LE
12	I do ask my students to watch business related movies showing warehousing and physical goods arrangement	2.01	0.95	LE
	Cluster mean and Standard deviation	2.20	0.96	LE

Table 2 reveals that to a low extent business education lecturers ask their students to download business related movies showcasing business operations environments, to watch certain movies that show different forms of businesses and their operations, to watch certain movies with scenes showing departmentalization of business organisation, to download certain movies from apps in order to screen them and learn customer's relationship and management, to watch certain movies downloaded from apps showing how capital are raised for starting own business, and to watch movies showing warehousing and physical goods arrangement with mean scores of 2.39, 2.10, 2.28, 2.21, 2.19, 2.01 and standard deviation scores of 1.01, 0.68, 1.16, 0.99, 0.98 and 0.95 respectively. Similarly, when the cluster mean score of 2.20 and standard deviation score of 0.96 are considered, it can be concluded that to a low extent business edutainment from Movies apps are being utilized by business education lecturers in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class

Research Question 3: To what extent are business edutainment in form of online documentaries utilized in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class?

Table 3: Summary of Mean Scores on the Extent to which Business Edutainment from Online Documentaries are Utilized in Tertiary Institutions in Rivers State

S/No	Online documentaries items	Mean	Std	Decision
13	I ask my students to watch business edutainment documentaries online about different family businesses grown into corporations.	2.07	0.77	LE
14	I refer my students to watch business edutainment in form of online documentaries about the economic development of different nations.	2.04	1.01	LE
15	I ask my students to watch business edutainment online documentaries about advertisement errors and effects.	2.12	0.92	LE
16	I ask students to download and watch business edutainment documentaries about businesses financing options.	1.96	0.90	LE
17	I ask my students to download and watch business edutainment from online documentaries about warehousing	2.45	1.17	LE
18	I do ask my students to watch business edutainment in form of online documentaries about business departmentalisation,	2.18	0.79	LE
	Cluster mean and Standard deviation	2.14	0.81	LE

Table 3 reveals business education lecturers opined that to a low extent they ask their students to watch business edutainment documentaries online about different family businesses, to watch business edutainment in form of online documentaries about economic development of different nations, to watch business edutainment about advertisement errors and effects, to download and watch business edutainment documentaries about business financing options, to download and watch business edutainment from online documentaries about warehousing, and to watch business edutainment in form of online documentaries about business departmentalization with mean scores of 2.07, 2.04, 2.12, 1.96, 2.45, 2.18 and standard deviation scores of 0.77, 1.01, 0.92, 0.90, 1.17, 0.79. In same vein, when the cluster mean score of 2.14 and standard deviation score of 0.81 are considered, it can be concluded that to a low extent business edutainment in form of online documentaries are utilized by business education lecturers in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class.

Test of Hypothesis

Hypothesis 1: There is no significant different between the extent to which business edutainment from YouTube, Movies Apps and in form of online documentations are utilized in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class.

Table 4: Summary of Analysis of Variance on Significant difference between the extent to which business edutainment from YouTube, Movies Apps and in form of online documentations are utilized in tertiary institutions in Rivers State

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	22.24	2	11.12	2.66	.07
Within Groups	2715.08	119	4.18		
Total	2737.32	121			

Table 4 shows between group sum of squares is 22.24, with 2 as degree of freedom and mean square of 11.12. The table also shows within group sum of squares is 2715.08 and 119 degree of freedom as well as mean square of 4.18. The total has 2737.32 sum of squares and 121 degree of freedom. The computed F ratio is 2.66 which is statistically not significant alpha at 0.07. Therefore, the null hypothesis which states that there is no significant different between the extent to which business edutainment from YouTube, Movies Apps and in form of online documentations are utilized in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class, is accepted; $F(2, 121) = 2.66$, $p>0.05$ at 0.07. This means the extent of utilization of all the sources of business edutainment assessed in this study is not significantly different.

Discussion of Findings

The results related to this specific objective one revealed that to a low extent business edutainment from YouTube channels is being utilized by business education lecturers in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class The finding emanated from the fact that business education lecturers opined that to a low extent they do refer their students to business edutainment from YouTube channels demonstrating the process of business decision making, describing how entrepreneurs carryout their business practices, showcasing business challenges and how they were handled, showing business management processes, showing different aspects of financial management and educating on office ergonomics and management. Corroborating the finding of this study, Greeves and Oz (2024) affirmed that there is poor understanding among students and instructors about the educational benefits of YouTube channel. This means there is need to create more awareness of the benefits of utilizing business edutainment from YouTube channels to solve the need of large class size.

The results related to this specific objective two revealed that to a low extent business edutainment from Movies apps are being utilized by business education lecturers in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class. This finding emanated from the fact that business education lecturers opined that they ask their students to download business related movies showcasing business operations environments, to watch certain movies that show different forms of businesses and their operations, to watch certain movies with scenes showing departmentalization of business organisation, to download certain movies from apps in order to screen them and learn customer's relationship and management, to watch certain movies downloaded from apps showing how capital are raised for starting own business, and to watch movies showing warehousing and physical goods arrangement. In agreement with the finding of this study, Funch et al (2016) revealed that although teachers and students are familiar with Videos, very few of these stakeholders' care to select films with content relating to their programme for teaching and learning purposes. The finding of this study revealed that business education lecturers are not leveraging on business edutainment to help their students as Roslim et al (2021) affirmed the impact of utilizing entertaining videos to include helping students to develop interest in their career paths, develop oral presentation skills and increased their motivation to participate in stage drama therefore decreasing their anxiety and tension.

The results related to this specific objective three revealed that to a low extent low extent business edutainment in form of online documentaries are utilized by business education lecturers in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class. This finding emanated from the fact that business education lecturers opined that to a low extent they ask their students to watch business edutainment documentaries online about different family businesses, to watch business edutainment in form of online documentaries about economic development of different nations, to watch business edutainment about advertisement errors and effects, to download and watch business edutainment documentaries about business financing options, to download and watch business edutainment from online documentaries about warehousing, and to watch business edutainment in form of online documentaries about business departmentalization. Contrary to the finding of this study, Cox et al (2017) revealed that mini-series of documented edutainment are highly utilized in increasing the confidence of the students. Nevertheless, it is important to note that the differences in findings must be as a result of the extent of user's awareness and support system for the utilization of edutainment from video sources based on environment of studies. Furthermore, the finding of this study revealed that business education lecturers are not leveraging on business edutainment to help their students' requisite skills as Huq (2023) reported when utilizing documented films students developed financial literacy skills for small scale businesses and the consciousness to promote own businesses even in environments where they are coping to survive.

The results also revealed that there is no significant different between the extent to which business edutainment from YouTube, Movies Apps and in form of online documentations are utilized in tertiary institutions in Rivers State as scalable educational technology solutions for teaching large class. This finding is based on the fact that business education lecturers opined that to a low extent they utilize the three sources or forms of business edutainment assessed to meet the demand of teaching large class size by referring their students to download and watch in order to learn certain themes.

Conclusions

Based on the findings of this study, it was concluded that business edutainment to a low extent is being utilized in tertiary institution in Rivers State as scalable educational technology solution to teaching large class size. This also leads to the conclusion that business education lecturers are poorly leveraging on the benefits of business edutainment as a scalable educational technology solution in addressing the problem of large class size. It was also concluded there are factors leading to their low extent utilization of this educational technology product as a scalable solution in teaching large class size, hence, the need to identify them and address them.

Recommendations

Based on the findings of the study and the conclusions drawn, the following recommendations are put forward for implementations:

1. Educational technologists need to create more awareness and educate Business education lecturers on the enormous benefits of using business edutainment from YouTube, online videos and online documentaries as scalable solutions to teaching large class size in tertiary institutions in Rivers State;
2. Educational technologists need to train business education lecturers in tertiary institutions in Rivers State on how to collaborate with experts from the film industry or performing art education department to write scripts with robust business content for the purpose of teaching large class size.
3. Educational technologists need to educate business education lecturers in tertiary institutions in Rivers State on how to create or select YouTube channels or online documentaries with business contents for the purpose of teaching large class size.

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A THEORETICAL FRAMEWORK FOR DEVELOPING AN ELECTRONIC CUMULATIVE RECORD SYSTEM: ENHANCING SCHOOL COUNSELLING IN KWARA STATE, NIGERIA

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Abstract
This paper presents a theoretical framework for the development of an Electronic Cumulative Record System (ECRS) tailored to the needs of school counsellors in Kwara State, Nigeria. Recognising the limitations of traditional paper-based record management—such as data loss, inefficiency, and restricted accessibility—this study integrates established theories, including User-Centred Design (UCD), the Technology Acceptance Model (TAM), and Agile software development methodologies to guide the creation of a context-sensitive digital solution. Through iterative engagement with end-users and incorporation of socio-technical considerations like infrastructural constraints, digital literacy, and data privacy, the framework prioritises usabilit y, security, and adoption potential. The resulting conceptual model offers a structured approach to designing scalable, secure, and user-friendly electronic record systems that address unique challenges in low- and middle-income educational environments. By bridging theoretical constructs with pragmatic development processes, this work contributes a replicable roadmap for advancing digital transformations in educational counselling. Future research directions include empirical evaluation to assess usability and impact on counselling effectiveness, thereby supporting broader implementation and policy development in resource-constrained settings.

Keywords: Electronic Cumulative Record System; School Counselling; User-Centred Design; Technology Acceptance Model; Educational Technology in LMICs

Introduction

Effective student support services are crucial for educational success, and school counsellors play an essential role in recording and managing student information to aid in their guidance activities. Traditionally, these records have been paper-based — a method fraught with challenges such as data loss, inaccuracies, and inefficiency in retrieval and update. These issues are especially pronounced in low-resource settings like Kwara State, Nigeria, where infrastructural constraints and limited technological adoption hinder modernisation.

The growing digital transformation in education presents a valuable opportunity to improve the quality and accessibility of counselling records through electronic solutions. An Electronic Cumulative Record System (ECRS) can facilitate accurate, secure, and easily accessible storage and retrieval of student counselling data, thereby empowering counsellors to deliver more effective support.

Despite the evident advantages, existing digital records systems are often inadequately adapted to local contexts, with gaps in usability, scalability, and user engagement. Within the Nigerian educational ecosystem, there remains a scarcity of digital systems designed with the specific challenges of school counsellors in mind, highlighting the urgent need for contextually relevant solutions.

Rationale for the Study

This paper presents a theoretical examination of the development process for an ECRS tailored to the needs of school counsellors in Kwara State. Drawing from established software development methodologies and relevant theoretical frameworks, such as User-Centred Design principles and the Technology Acceptance Model (TAM)—this study examines how these can guide the creation of a system that addresses local infrastructural, usability, and privacy concerns.

Focusing on the development process rather than empirical evaluation, this work contributes a conceptual model and development roadmap that can support effective digital record keeping within similar low- and middle-income educational contexts.

Research Problem

Existing electronic record-keeping solutions often lack contextual adaptation, leading to low adoption rates among school counsellors in Nigeria. Challenges such as limited digital literacy, infrastructure inadequacies, and privacy concerns further impede the deployment and sustained use of such systems. There is limited theoretical work documenting how to systematically approach the development of electronic cumulative record systems that are both functional and aligned with users' real-world needs in Nigeria.

Objectives

The primary objectives of this theoretical study are to:

- Develop a comprehensive theoretical framework for the design and development of an Electronic Cumulative Record System tailored for school counselling in Kwara State.
- Articulate the guiding principles, development methodologies, and design choices needed to address contextual challenges.
- Provide a foundational conceptual model to inform future practical implementations and empirical evaluations.
- Bridge the gap between theory and practice in the digital transformation of educational counselling record management within low-resource settings.

Literature Review

The use of electronic cumulative record systems (ECRS) in educational contexts has steadily gained attention as a means to enhance the efficiency and accuracy of student data management. Rose and Thomas (2020) emphasise the critical role of user-centred design in ensuring that educational technologies meet the diverse needs of school staff, noting that usability and accessibility directly impact adoption rates among educators. Their findings highlight that systems which fail to account for varying levels of digital literacy may face resistance and underutilization. In the context of low- and middle-income countries (LMICs) like Nigeria, infrastructural and contextual challenges further complicate the deployment of digital counselling tools. A recent study by Popoola, Kareem, and Oduola (2025) investigating Nigerian counsellors' awareness and readiness to use social media platforms for counselling services found that while counsellors are generally familiar with these digital tools, several barriers hinder their effective utilisation. Key challenges include poor internet connectivity, insufficient training and support, and cultural and religious constraints. Despite these obstacles, the study highlights the considerable potential of social media to enhance counselling service delivery in Nigeria by fostering greater collaboration among counsellors and improving access to support, particularly in remote and underserved areas. This underscores the importance of designing digital solutions that are both accessible and contextually relevant.

Digital counselling interventions have shown promise for improving mental health outcomes among students when carefully implemented. Calear et al. (2015) conducted a randomised controlled trial of the "Bite Back" positive psychology program in Australian schools, illustrating that web-based interventions can boost life satisfaction but require strategic implementation to maximise engagement. Similarly, Anttila et al. (2019) demonstrated the acceptability of web-based mental health programs in Thailand, underscoring that cultural and contextual tailoring is paramount for success.

From a theoretical standpoint, established models like the Technology Acceptance Model (TAM) provide useful frameworks for understanding factors that influence the adoption of new technologies by school counsellors (Davis, 1989). TAM underscores perceived usefulness and ease of use as core determinants shaping intention to use digital tools, making it particularly relevant in guiding the conceptualisation and design phases of ECRS development.

Collectively, this literature affirms the importance of combining robust theoretical frameworks with contextually sensitive design and development approaches to create effective electronic record systems that are feasible and sustainable in resource-constrained educational settings.

Development Process and Theoretical Framework

Theoretical Foundations Guiding Development

The development of the Electronic Cumulative Record System (ECRS) was grounded in established theoretical frameworks that emphasise user engagement, system usability, and technology adoption, specifically:

User-Centred Design (UCD): UCD principles (Norman, 2013) guided the development process to ensure that end-users—school counsellors in Kwara State—were actively involved in system design. This framework advocates iterative refinement of design artifacts based on continuous user feedback, focusing on usability, accessibility, and task efficiency. Given the digital literacy variability and contextual constraints, UCD served as a vital construct to tailor the system to actual user needs and workflows.

Technology Acceptance Model (TAM): Rooted in Ajzen and Fishbein's Theory of Reasoned Action, TAM (Davis, 1989) was used to conceptualise factors influencing the adoption of ECRS. Key constructs such as perceived usefulness and perceived ease of use framed design decisions to encourage system acceptance by addressing counsellors' attitudes and behavioural intentions toward the technology.

Agile Methodology: The Agile software development framework (Beck et al., 2001) was employed to support iterative, incremental development with flexibility to adapt requirements throughout the project lifecycle. Agile's emphasis on stakeholder involvement and evolving product increments aligned well with the UCD and TAM principles, facilitating continuous integration of user input and theoretical insights into development cycles.

Development Methodology

The development process involved the following phases, explicitly tied to the above theoretical models:

1. Requirements Elicitation and Analysis: Semi-structured interviews and focus group discussions were conducted with school counsellors to gather contextual requirements and identify pain points with existing record-keeping practices. Using UCD, stakeholders' feedback prioritised functionalities such as ease of access, data security, and appointment scheduling, ensuring alignment with users' cognitive models and workflows.
2. Conceptual Framework and System Design: Based on gathered requirements and TAM constructs, a conceptual framework was designed, highlighting factors affecting usability and behavioural intention to use the ECRS. Low-fidelity prototypes and system architecture diagrams were developed to demonstrate data flow, security layers, and user interfaces. Special attention was given to ensuring simplicity to maximise perceived ease of use and usefulness.
3. Iterative Development and Prototyping: Agile sprints were employed, producing working increments of the ECRS. After each sprint, prototype versions were reviewed by domain experts and a small subset of end-users to apply UCD principles. Iterative adjustments improved usability and addressed technical constraints related to infrastructure in Kwara State's school environments.
4. Technology Selection and Implementation: The technology stack, including Laravel framework, PHP, JavaScript, HTML, and CSS, was selected based on scalability, security features, and ease of maintenance. These technical choices reflected theoretical concerns from TAM about reliability and performance as predictors of technology acceptance.
5. Ethical and Privacy Considerations: Inspired by principles from information security theory (Whitman & Mattord, 2011) and ethical guidelines for educational technologies, the system incorporated data privacy mechanisms to protect student information and comply with local regulations. Ensuring confidentiality and trust was considered critical for user acceptance and sustained use.

Conceptual Model of Development

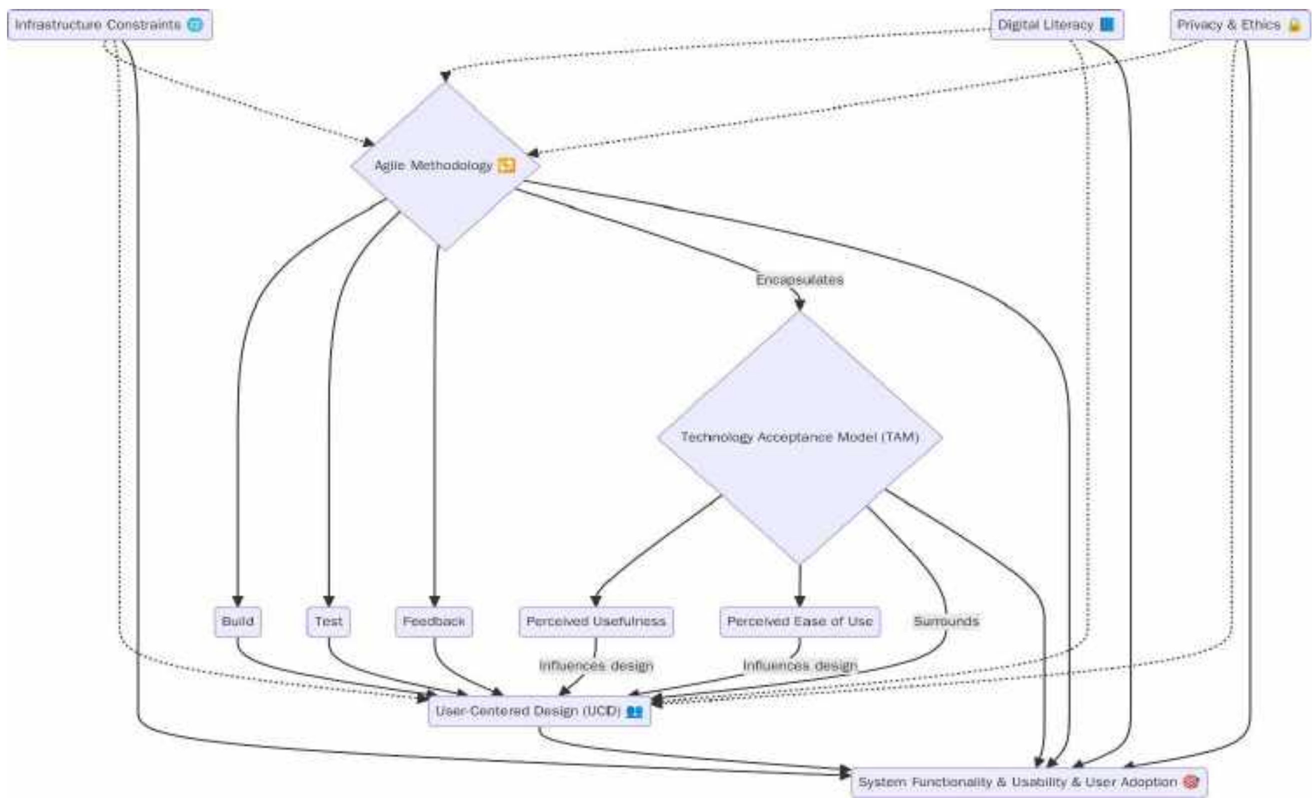

Figure 1: Conceptual Framework integrating UCD, TAM, and Agile for ECRS Development]
This conceptual model illustrates the interplay between user requirements, theoretical perceptual constructs from TAM, iterative development activities from Agile, and the continuous feedback loops fundamental to UCD. The model highlights how theoretical insights shaped iterative system refinement, ensuring contextual appropriateness, usability, and acceptability.

Development Process and Theoretical Framework

The development of the Electronic Cumulative Record System (ECRS) for school counsellors in Kwara State followed a structured, theory-driven approach that integrates established software development methodologies with behavioural and usability theories to ensure the system's effectiveness, contextual fit, and user acceptance.

Theoretical Foundations Guiding Development

The system design was primarily guided by the User-Centred Design (UCD) Framework, which emphasises involving end-users—school counsellors in this context—at each stage of development to tailor the system closely to their needs, preferences, and workflows (Norman, 2013). UCD is critical in educational technology because it addresses usability challenges, especially for users with varying levels of digital literacy, by focusing on continuous feedback and iterative refinement. Complementing this, the Technology Acceptance Model (TAM) (Davis, 1989) informed the considerations around factors influencing system adoption. Perceived usefulness and ease of use—the central constructs of TAM, shaped development priorities such as simplifying interfaces, ensuring quick data retrieval, and maintaining data security. Awareness of these determinants guided the development team to design features that explicitly address counsellors' concerns and motivations regarding technology use.

Software Development Methodology: Agile Approach

Given the dynamic needs of the school counselling context and the likelihood of evolving user requirements, the Agile software development methodology was adopted as the core framework for the ECRS development (Beck et al., 2001). Agile's iterative and incremental process allowed for flexibility, rapid prototyping, and early incorporation of user feedback obtained through consultations with school counsellors in Kwara State. This ensured that the system remained aligned with real-world challenges such as infrastructural constraints and workload pressures.

The development cycle included:

- Requirement Gathering and Analysis: Semi-structured interviews and focus group discussions with counsellors and educational administrators to identify functional and non-functional requirements.
- System Design: Creation of high-level architecture diagrams, data models, and user interface mockups, all grounded in UCD principles.
- Incremental Development: Modular implementation using PHP, Laravel, HTML5, CSS, and JavaScript to ensure maintainability and responsiveness.
- Regular User Feedback Loops: Demo sessions and usability consultations enabled iterative refinement, improving system intuitiveness and performance.

Contextual and Ethical Considerations

The design process was mindful of the socio-technical environment in Kwara State schools, including limited internet connectivity, variable computer literacy levels among counsellors, and privacy concerns stemming from the sensitive nature of counselling records. Incorporating principles from Ethical Frameworks for Digital Data Handling (Mittelstadt, 2017), the system features secure authentication, encrypted data storage, and compliance with confidentiality protocols to safeguard student information.

Ethical and privacy considerations were a critical part of the system design process, informed by recent expert consensus on managing sensitive behavioural and psychiatric data (Zhao et al., 2024). This framework advocates for classifying data sensitivity levels and applying rigorous data protection measures, including minimising data collection, securing informed consent, employing advanced encryption methods, multi-factor authentication, and strict access controls to safeguard confidential student information. The study's emphasis on ethical review processes, data use agreements, and education underscored the need for accountability and trust, especially in contexts where sensitive counselling information is managed digitally. These guidelines provided a foundational ethical reference supporting secure, privacy-compliant handling of educational counselling records.

Conceptual Model of Development

The theoretical development process for the ECRS can be summarised as an iterative cycle involving:

1. User Needs Identification (UCD)
2. Technology Acceptance Factors Integration (TAM)
3. Agile-Based Prototyping and Development
4. Contextual Adaptation (Infrastructure & Societal Context)
5. Ethical Safeguards Implementation

System Architecture

The ECRS adopts a three-tier client-server architecture comprising:

Presentation Layer (Front-End): The user interface was developed using HTML5, CSS, and JavaScript, designed for responsiveness and accessibility. This layer ensures an intuitive interaction experience by adhering to UCD guidelines, minimising cognitive load, and supporting both desktop and mobile devices commonly available in Kwara State schools.

Application Layer (Back-End): Implemented using the Laravel PHP framework, this layer handles business logic, input validation, session management, appointment scheduling, and self-help resource management. Employing Laravel's MVC (Model-View-Controller) structure facilitates modularity and maintainability. Agile methodologies informed the incremental addition of features, ensuring flexibility and responsiveness to user feedback.

Database Layer: A relational database management system (RDBMS) stores encrypted student counselling records, appointment logs, user profiles, and resource metadata. Data modelling adheres to confidentiality principles, ensuring normalisation and integrity, with access controls enforced at this level to comply with privacy standards emerging from educational ethical frameworks.

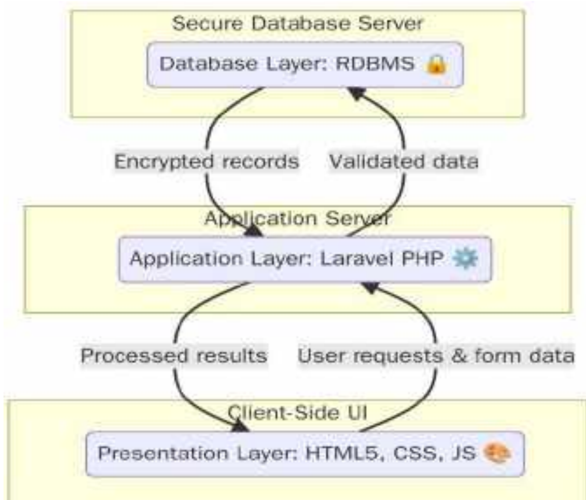

Figure 2: *System Architecture Diagram*
(A conceptual diagram illustrating the three tiers: client-side UI, application server, and secure database server, with arrows indicating data flow and interaction.)

User Workflow

The user workflow was designed with a focus on simplicity and task efficiency, aligning with TAM's perceived ease of use. Key user activities include:

Authentication: Secure login authenticates counsellors before granting system access, ensuring privacy and data security.

Record Management: Counsellors can create, update, review, and archive cumulative student records, enjoying prompt retrieval via search functionalities.

Appointment Scheduling: A built-in calendar allows counsellors to manage sessions and students to request appointments, streamlining support access.

Self-Help Resources: Students and counsellors can access curated digital resources, enhancing independent support pathways.

Reporting: Counsellors can generate summary reports on student progress and session outcomes for administrative or follow-up purposes.
Each step in this workflow is designed to minimize navigation complexity, validated in line with formative UCD feedback loops to optimize user satisfaction and effectiveness

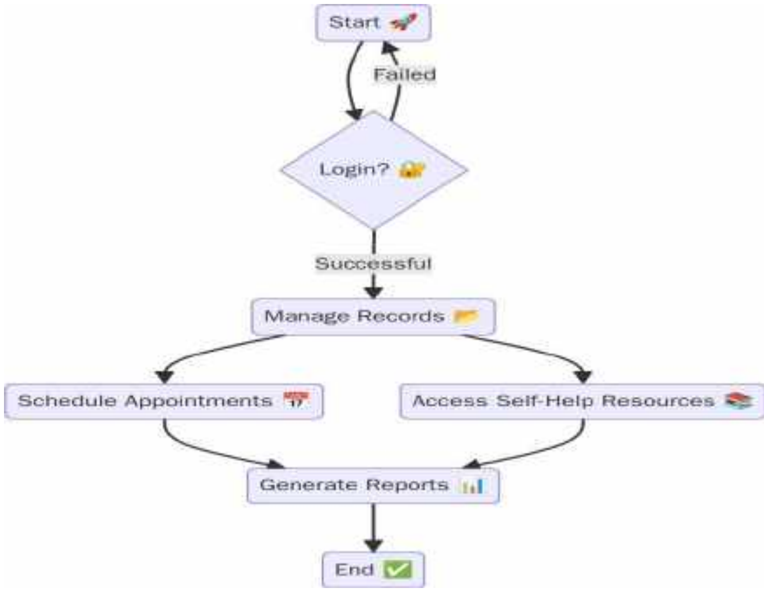

Figure 3: *User Workflow Diagram*
(A flowchart mapping the sequential user interactions, highlighting decision points such as login, record entry, scheduling, and report generation.)

Data Models
The relational data model underpinning the ECRS reflects the core components of counselling data management:
Entities:
Student: Demographic and academic identifiers.
Counsellor: User information, access permissions.
CumulativeRecord: Entries detailing counselling sessions, issues addressed, recommendations.
Appointment: Scheduling data including date, time, status, and student-counsellor linkage.
Resource: Metadata of self-help digital materials.
Relationships:
One-to-many between Counsellor and CumulativeRecord (a counsellor manages multiple student records).
One-to-many between Student and Appointment (a student can have multiple scheduled sessions).
Referential integrity constraints ensure consistent connections among related entities.
The data model was specifically designed to support fast queries and secure data retrieval, addressing counsellor-identified pain points related to inefficiencies in the traditional system.

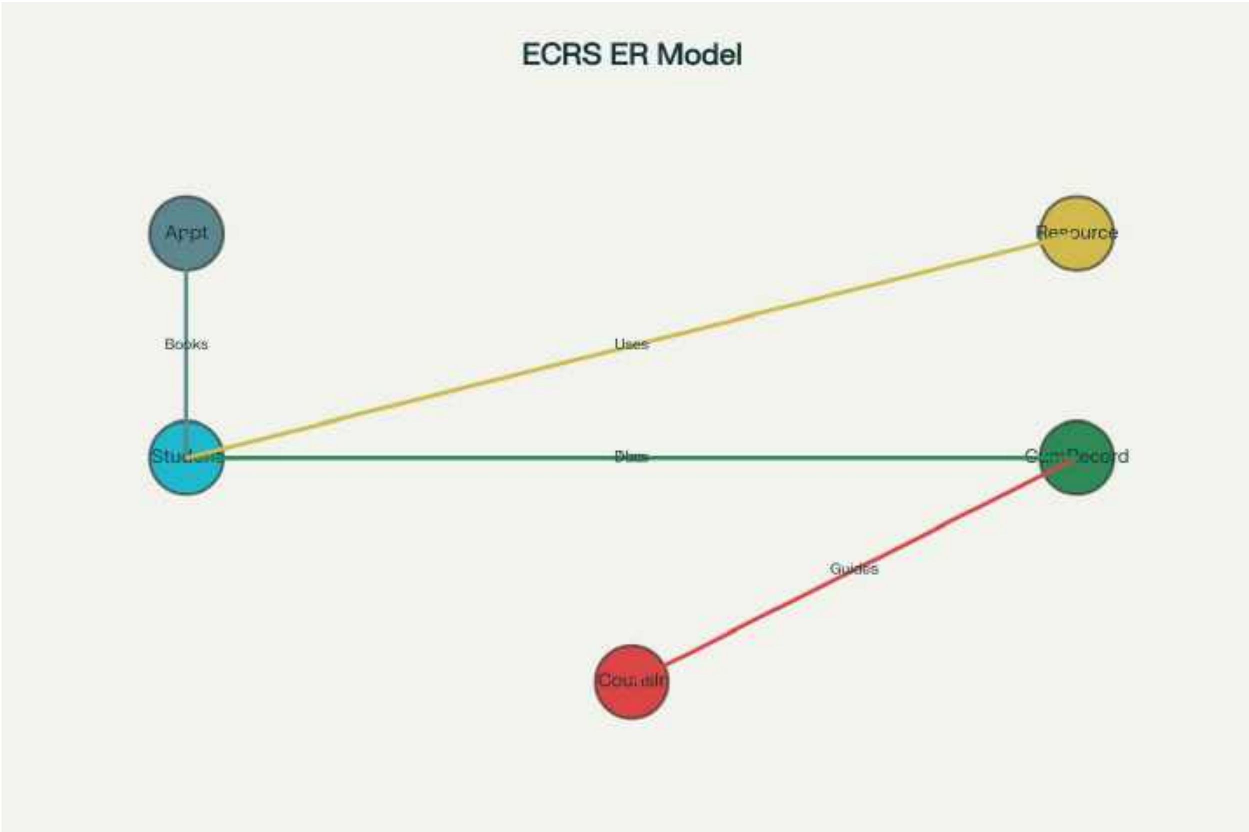

Figure 3: Entity-Relationship (ER) Diagram
(Diagram illustrating entities and their relationships with cardinality notation, emphasizing security and usability.)
Entities:
[Student]
- StudentID (PK)
- Name
- DateOfBirth
- Gender
- AcademicYear
- Other demographic/academic attributes
[Counsellor]
- CounsellorID (PK)
- Name
- ContactInfo
- AccessLevel
[CumulativeRecord]
- RecordID (PK)
- StudentID (FK)
CounsellorID (FK)
- SessionDate
- IssuesAddressed
- Recommendations

- Notes
[Appointment]
- AppointmentID (PK)
- StudentID (FK)
- CounsellorID (FK)
- AppointmentDate
- AppointmentTime
- Status
[Resource]
- ResourceID (PK)
- Title
- Description
- URL/Location
- ResourceType
Relationships:
Counsellor 1 --- * CumulativeRecord
(A counsellor manages multiple cumulative records)
Student 1 --- * Appointment
(A student can have multiple appointments scheduled)
Counsellor 1 --- * Appointment
(A counsellor manages multiple appointments)
Student 1 --- * CumulativeRecord
(A student may have multiple counselling records)
(Note: Referential integrity constraints enforce that CumulativeRecord.StudentID and CumulativeRecord.CounsellorID reference valid Student and Counsellor entries, respectively; likewise for Appointment.)
Summary:
- Primary Keys (PK) uniquely identify each entity's records.
- Foreign Keys (FK) establish links between entities per relationships.
- Cardinalities shown indicate one-to-many relationships.

Discussion

The development of the Electronic Cumulative Record System (ECRS) was fundamentally shaped by the integration of established theoretical frameworks—namely the User-Centred Design (UCD) approach and the Technology Acceptance Model (TAM)—combined with the Agile software development methodology. These frameworks collectively ensured that development decisions were not only technically sound but also deeply responsive to user needs, contextual limitations, and adoption factors specific to low- and middle-income country (LMIC) educational settings.

The UCD framework was instrumental in centring the perspectives, workflows, and usability challenges of school counsellors in Kwara State throughout the system's design and iterative refinement. By actively involving end-users via interviews, focus groups, and prototype feedback sessions, development efforts were consistently aligned with the real-world tasks and cognitive models of counsellors. This approach mitigated the risks typically associated with digital tool rejection due to complexity or mismatch with user capabilities, which are prevalent barriers in LMIC contexts where digital literacy may vary widely.

TAM provided a conceptual lens to foreground critical determinants of technology acceptance—perceived usefulness and perceived ease of use. These constructs informed key design priorities such as simplifying interfaces, ensuring rapid data access, and embedding robust security features. This theoretical sensitivity helped preempt common adoption obstacles such as concerns over data privacy, system reliability, and procedural complexity, which have posed challenges in prior attempts to digitalise educational counselling systems in similar resource-constrained settings.

The Agile methodology complemented these behavioural and design frameworks by enabling a flexible, iterative development process. This allowed the development team to incorporate timely user feedback and adapt to infrastructural constraints unique to the local environment—such as intermittent internet connectivity and varied hardware availability. Agile's incremental delivery ensured that each module was tested against theoretical usability and acceptance benchmarks before progressing, enhancing system stability and relevance.

Theoretically, this development process contributes a holistic framework combining behavioural theories and technical methodologies tailored to LMIC educational technology projects. It underscores the importance of embedding sociotechnical perspectives, considering human factors, contextual realities, and infrastructural limitations—within software development cycles for digital health and educational tools.

By explicitly documenting the integration of UCD, TAM, and Agile within a pragmatic development roadmap, this study fills a notable gap in the literature where electronic cumulative record systems often lack contextual adaptation and theoretical grounding. It offers a replicable model for practitioners and researchers seeking to design educational technologies that are usable, accepted, and sustainable in similar LMIC environments.

Furthermore, this work highlights critical insights into balancing theoretical rigour with practical constraints, such as privacy concerns and digital literacy variability, emphasising that successful digital transformations in education demand more than technology deployment—they require comprehensive, theory-informed development strategies sensitive to local realities. This has broad implications for advancing educational technology implementation frameworks that can contribute to equitable, data-driven student support services globally.

Conclusion

This paper has presented a theoretical framework and detailed development process for an Electronic Cumulative Record System (ECRS) tailored to school counselling services in Kwara State, Nigeria. Grounded in the User-Centred Design (UCD) approach, the Technology Acceptance Model (TAM), and Agile software development principles, the system was conceptualised and built to address the unique infrastructural, digital literacy, and privacy challenges prevalent in low- and middle-income country (LMIC) educational settings.

The development methodology emphasised iterative engagement with end-users, ensuring the system's design met real-world needs while promoting ease of use, perceived usefulness, and data security, key factors influencing technology acceptance. By integrating behavioural theories with flexible development practices, this work bridges a significant gap between theoretical models and pragmatic system design adapted for resource-constrained environments.

Importantly, the theoretical model and development roadmap outlined here provide a replicable blueprint for similar educational technology initiatives aiming to improve data-driven counselling and student support services in LMICs. This study also foregrounds the necessity of considering socio-technical and ethical dimensions, including confidentiality and infrastructural constraints, when designing digital health and education tools.

While this paper focuses on the theoretical development process, future research should empirically evaluate the system's usability, effectiveness, and impact on counselling outcomes.

Such evaluation will be critical for validating the framework's goals and informing larger-scale implementation.

Ultimately, this work contributes to advancing digital transformations in education by demonstrating how rigorous, theory-informed development processes can foster sustainable, contextually relevant solutions that empower school counsellors to better support student success through enhanced data management.

Final Note

This paper is theoretical and development-focused; it is appropriate to clearly state that system evaluation is beyond this manuscript's scope , but remains a vital future step. This clarifies your paper's contribution while managing reader expectations.

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HARNESSING AI FOR INCLUSIVE AND INNOVATIVE LEARNING AND RESEARCH AMONG PRE-SERVICE BIOLOGY TEACHERS' IN KWARA STATE COLLEGES OF EDUCATION

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Abstract

The study examined the integration of Artificial Intelligence (AI) tools in promoting inclusive and innovative learning and research among pre-service biology teachers in Colleges of Education in Kwara State, Nigeria. Using a descriptive survey design, data were collected from 73 randomly selected pre-service biology teachers across three institutions. A structured questionnaire explored the extent of AI integration, utilization for research and pedagogical innovation, and perceptions, competencies, and concerns regarding AI adoption. Findings revealed a generally high level of AI integration in teacher training, with most respondents affirming the use of AI for lesson planning, supporting diverse learners, and enhancing research output. AI tools such as ChatGPT, Grammarly, and Quillbot were widely used for academic purposes, while confidence in AI's potential to make teaching more engaging was strong. However, concerns about ethical issues, potential teacher replacement, and the need for further training were notable. The study concludes that while AI adoption in pre-service biology education is promising, sustained institutional support, targeted AI literacy programs, and robust policy frameworks are essential for maximizing its potential.

Introduction

In today's knowledge driven world, the demands on education systems are evolving rapidly, necessitating innovative teaching practices and inclusive learning environments that can cater to diverse learner needs. The development of many countries is greatly influenced by science. According to Bradford and Hamer (2022) defined science as a systematic and logical method used to determine the mechanisms by which everything in the universe functions. It can also be defined as a collection of information gathered and combined through methods for figuring out the nature of everything in the universe. The branches of science include pure science and applied science. Pure science includes chemistry, physics, and Biology. Biology as a subject is concerned with the study of life and living organisms, including their structure, function, growth, evolution, distribution, and taxonomy. Bios means life and logo means study of science (Lim & Dutfield, 2022). Biology can be best taught when technology is introduced into teaching.

Technology however has shifted educational practices from conventional methods to more engaging, and digitalized formats. The integration of technology into various sectors is not merely a trend but a necessity for progress (Luckin et al., 2024). In education, technology can facilitates enhanced learning experiences and research capabilities. In broader contexts, it drives efficiency, addresses societal challenges, and fosters innovative (Olusola & Ogunleye, 2020). This technological gap not only hinders innovation in instructional practice but also undermines equity in learning, especially when pre-service teachers are not trained to support learners with diverse needs using available technological resources (Luckin et al., 2016). Advancement in technology has generated fresh opportunities for renovating instructional methodologies. Generative AI applications, such as ChatGPT and DALL-E, have developed as great tools in education. These applications facilitate the development of lesson plans, enables the creation of interactive simulations of depicting biological processes, and offer personalized feedback to learners, thereby supporting more effective teaching and learning experiences (Jimba-Na'Allah et al., 2024).

Artificial intelligence (AI), once a futuristic concept, is now reshaping various sectors including education through its capacity to personalize learning, streamline instructional delivery, and enhance data informed decision making (Holmes et al., 2019). Within this transformation, the education of teacher particularly pre-service teachers plays a crucial role in preparing future educators for classrooms increasingly influenced by intelligent technologies.

Pre-services teacher education serves as the foundation for equipping future educators with both content knowledge and pedagogical skills. However, many teacher preparation programs, particularly in low and middle income countries, remain largely traditional in their structure, lacking integration of 21st century tools such as AI (Lumanlan, 2025). Pre-service teachers increasingly view artificial intelligence (AI) applications as valuable tools for enhancing teaching and learning experiences. In the submission of Alejandro et al., (2024), opined AI technologies facilitate personalized learning, data driven instruction, and adaptive feedback, allowing educators to better address students learning gaps. However, the successful adoption of these tools depends on various psychological and contextual factors. AI-driven tools such as intelligent tutoring systems, content generation platforms such as ChatGPT, Gemini, and Perplexity among others, and adaptive learning environments have the potential to foster inclusive pedagogy and enrich academic research among teacher trainees (Xie et al., 2022)

Despite growing awareness of AI's capabilities, there is limited empirical research focusing on how pre-service teachers interact with these tools, what competencies they develop, and how institutional structures either enable or constrain AI adoption. Concerns about ethics, digital inequality, lack of infrastructure, and insufficient faculty modeling continue to pose serious challenges (Owolarafe et al., 2024). At the same time, global case studies from countries such as Ghana, Germany, and the Philippines suggest that structured AI training, cultural responsiveness, and policy alignment can significantly enhance AI acceptance and efficacy in teacher education (Lacuna, 2025; Zhang et al., 2023; Nyaaba, 2025)

Statement of the Problem

The traditional model of teacher education in many developing countries including Nigeria, is struggling to keep pace with the demands of 21st century learning, particularly in terms of inclusivity and innovation. Pre-service biology teachers' training often lacks exposure to cutting edge technologies such as Artificial Intelligence (AI), which have the potential to transform both learning experiences and research capacity. Despite the global surge in AI adoption across sectors, many pre-service biology teachers remain ill equipped to use AI tools effectively for lesson planning, differentiated instruction, and academic inquiry. Furthermore, concerns regarding infrastructure, digital literacy, ethical considerations, and institutional readiness persist. These challenges pose significant risks to educational equity and the professional preparedness of future teachers. Therefore, there is an urgent need to explore how AI can be systematically harnessed to support inclusive and innovative practices in pre-service biology teacher education, and to access the perceptions, competencies, and limitations influencing its adoption.

Purpose of the Study

The general purpose of this study is to investigate the integration of Artificial Intelligence (AI) tools in promoting inclusive and innovative learning and research among pre-service biology teachers in Colleges of Education in Kwara State, Nigeria. Specifically, the study seeks to:

1. Determine the extent to which AI tools are being integrated into pre-service biology teacher education to support inclusive learning practices.
2. Examine how pre-service biology teachers utilize AI technologies to enhance their research skills and pedagogical innovation.
3. Assess the perceptions, competencies, and concerns of pre-service biology teachers regarding the use of AI tools in their training programs.
4. Identify institutional and contextual factors that influence the adoption of AI for inclusive and innovative learning.

Research Questions

1. To what extent are Artificial Intelligence (AI) tools being integrated into pre-service biology teacher education to support inclusive learning practices in Colleges of Education in Kwara State?
2. How do pre-service biology teachers in Kwara State Colleges of Education utilize AI technologies to enhance their research skills and promote innovation in teaching practice?
3. What are the perceptions, competencies, and concerns of pre-service biology teachers regarding the use of AI tools in their teacher education programs in Kwara State?

Literature Review

Concept of AI in Teacher Education

Artificial intelligence (AI) is a technology from adaptive tutoring engines to large language models (LLMs) and generative AI, are entering classrooms and teacher education programs at pace. According to Ogunode and Ukozor (2023) defined AI as the machines that have the capacity to carry out tasks that are meant to be performed by human intelligence. Artificial Intelligence (AI) refers to the simulation of human intelligence processes by machines, particularly computer systems, to perform tasks such as learning, reasoning, problem-solving, and decision-making (Xiaoyang, 2023). In education, AI is increasingly being adopted to enhance teaching and learning processes, streamline administrative functions, and promote innovation in instructional delivery (UNESCO, 2019). Teacher education, on the other hand, encompasses the structured training, professional preparation, and continuous development of individuals to become qualified educators, particularly at primary, secondary, and tertiary levels (Usman & Okoye, 2024). The relationship between AI and teacher education lies in AI's capacity to transform the management of teacher training programmes through tools that improve curriculum design, automate administrative tasks such as student enrolment and record-keeping, and provide adaptive learning platforms that cater to diverse learning needs (Usman & Okoye, 2024). In Nigeria, particularly in Federal Colleges of Education, the integration of AI remains limited, with most institutions still relying on conventional ICT tools rather than fully embracing AI-driven systems due to infrastructural, technical, and policy constraints (Usman & Okoye, 2024). However, the potential of AI to improve teacher education is substantial, as it can support innovative teaching practices, data-driven decision-making, and personalized professional development, thereby aligning teacher preparation with 21st-century educational demands.

Biology Education in Colleges of education

The Colleges of Education are teachers' training institutions created to cater for students who are potential teachers, and they are awarded National Certificate in Education (NCE), after the completion of their three years training. The National Commission for Colleges of Education (NCCE), are the body in charge of all the affairs of Colleges of Education. One of the several programs suggested by NCCE is the Biology Education. Students admitted into biology education must take biology and one other related subject in order to complete two teaching subjects. Biology education is an important component of students' worldwide and knowledge base, giving them the groundwork to continue their education or work in the sphere of life science (Umeohana, 2024).

In the submission of Bizimana, Mutangana, and Mwesigye, (2021), opined biology as the study of life and pure science. The subject is very important to the development of society most especially for undergraduates pursuing their careers in pharmacy, medicine, Nursing and those proposing to be a biology teacher. Biology education refers to biology instruction that teaches individuals about their bodies, identities, and how those bodies work. Therefore, biology education is the application of educational concepts to biology instruction. The ability to affect or transmit biology knowledge to students requires mastery of teaching and training skills (Farounbi, 2014).

Nigerian Colleges of Education's NCE Biology programs aim to produce teachers who can: view biology as a process of inquiry into the living world; critically evaluate the actions of living things in their surroundings; demonstrate practical skills in handling scientific apparatus; teach biology with excellence and professionalism; promote positive views towards biological science and scientific endeavors in society and incorporate positive scientific attitudes and values throughout; apply course knowledge to new fields of study and to situations that arise in daily life; make a successful career in biology teaching, and obtain the credentials required to enrol in a B. SC(ED) degree program.

The minimum standards for teacher educators in colleges of education outline the basic minimum that educators must know and be able to do, as well as the minimal attitudes that educators should have toward their profession, if they wish to continue and grow in their careers (Nigeria's Minimum Education Certificate Standard, 2013). Courses such as Cell Biology, basic biological principles, bacteria, viruses, and lower plants; ecology; diversity of invertebrates; animal histology; research methods and biometry; Biology practical IV; diversity of chordates; population education; plant pathology; animal histology; evolution; laboratory management; applied biology; introductory parasitology; genetics; biology practical V; plant physiology; vertebrates; anatomy and physiology.

These courses, along with other second teaching subjects like Chemistry, Physics, Mathematics, Integrated Science, Computer Science, Physical and Health Education, and General Studies; Education Courses, including Teaching Practice (TP); and other activities, are accredited and recognized by the National Commission for Colleges of Education (NCCE). Successful completion of these activities results in the awarding of a Nigeria Certificate in Education.

Methodology

The study adopts a descriptive research design of survey type. Survey method of descriptive study was chosen because of the type of data collected through quantitative approach. The descriptive survey method was adopted to obtain information from Pre-service biology teachers. The population of the study consists of all pre-service teachers in state owned colleges of education in Kwara State. The target populations are pre-service biology teachers in the three colleges of education in Kwara State. The total of 73 pre-service biology teachers was randomly selected from all the three colleges of education for the study. A structured questionnaire was employed as the primary data collection via Google form which was sent to each lecture in the department of biology of the three colleges of education. The questionnaire was designed with multiple sections each corresponding to specific research questions related to the study.

Results and Discussion

Presentation of Results

SECTION A: Presentation of Demographic Data

Table 1:

Information on gender

Gender	Frequency	Percentage (%)
Male	31	41.9%
Female	42	58.1%
Total	**73**	**100%**

Table one shows that out of the 73 participants in the study, 31 were male, making up 41.9% of the total, while 42 were female, representing 58.1%. This indicates that female participants slightly outnumbered male participants, suggesting a modest gender imbalance in favor of females in the sample.

Table 2:

Information on the level of respondents

Level	Frequency	Percentage (%)
100	10	13.7%
200	21	28.8%
300	42	57.5%
Total	**73**	**100%**

Table two shows that among the 73 respondents, 10 were in 100 level (13.7%), 21 were in 200 level (28.8%), and 42 were in 300 level (57.5%). This indicates that the majority of participants were in 300 level, followed by those in 200 level, with 100 level students making up the smallest group in the sample.

Table 3:
Information on Institution

Institution	Frequency	Percentage (%)
College A	42	57.5%
College B	4	5.5%
College C	27	37.0%
Total	**73**	**100%**

Table three reveals that 42 respondents (57.5%) were from College A, making it the largest group in the study. College C followed with 27 respondents (37.0%), while College B had the smallest representation, with only 4 respondents (5.5%). This shows that more than half of the participants came from College A, while College B contributed very few respondents compared to the other institutions.

Research Questions 1: To what extent are Artificial Intelligence (AI) tools being integrated into pre-service biology teacher education to support inclusive learning practices in Colleges of Education in Kwara State?

Extent of AI tools integration into Pre-services Biology Education

S/N	**Extent of AI tools integration into Pre-services Biology Education**	**SA**	**A**	**D**	**SD**	**MEAN**
1.	AI tools are frequently used during my teacher training classes to support learning diversity.	29(39,2%)	40(54.1%)	03(4.1%)	01(1.4 %)	1.67
2.	My institution provides access to AI-based platforms for inclusive lesson delivery.	19(25.7%)	37(50.0%)	15(20.0%)	02(2.7 %)	2.00
3.	AI technologies are incorporated into our teaching methods courses for inclusive learning practices.	24(32.4%)	28(37.8%)	20(27.0%)	01(1.4 %)	1.97
4.	I am encouraged to use AI applications to address the needs of diverse learners.	31(41.9%)	36(48.6%)	05(6.8%)	1(1.4 %)	1.67

Table four presents respondents' views on the extent of AI tools integration into pre-service biology education. For the first item, 39.2% strongly agreed and 54.1% agreed that AI tools are frequently used during teacher training classes to support learning diversity, while only a small proportion disagreed (4.1%) or strongly disagreed (1.4%). The low mean score of 1.67 indicates a high level of agreement. On the second item, 25.7% strongly agreed and 50.0% agreed that their institution provides access to AI-based platforms for inclusive lesson delivery, whereas 20.0% disagreed and 2.7% strongly disagreed. The mean score of 2.00 still reflects overall agreement, though slightly lower than in the first item. For the third items, 32.4% strongly agreed and 37.8% agreed that AI technologies are incorporated into teaching methods courses for inclusive learning practices, with 27.0% disagreeing and 1.4% strongly disagreeing. The mean score of 1.97 suggests general agreement, though with a noticeable portion expressing dissent.

Finally, regarding encouragement to use AI applications to address the needs of diverse learners, 41.9% strongly agreed and 48.6% agreed, while only 6.8% disagreed and 1.4% strongly disagreed. The mean score of 1.67 again shows strong consensus in favor of the statement. Overall, the responses indicate that most participants perceive AI tools as being actively integrated into their teacher training, especially in supporting diverse learners, though access to AI-based platforms appears slightly less consistent.

Research Question 2: How do pre-service biology teachers in Kwara State Colleges of Education utilize AI technologies to enhance their research skills and promote innovation in teaching practice?

S/N	How do pre-service teachers utilize AI technologies to enhance their research skills and innovation in practice?	SA	A	D	SA	MEAN
5.	I have used AI tools (e.g., ChatGPT, Grammarly, Quillbot) in conducting research assignments or projects.	31(41.9%)	35(47.3%)	7(9.5%)	0(0%)	1.67
6.	AI technologies have helped me generate innovative ideas for lesson planning and teaching strategies.	28(37.8%)	35(47.3%)	08(10.8%)	02(2.7%)	1.78
7.	I use AI tools to assist in structuring or analyzing academic papers.	19(25.7%)	43(58.1%)	10(13.7%)	01(1.4%)	1.90
8.	AI has improved the quality and creativity of my research output.	15(20.3%)	46(62.2%)	11(14.9%)	01(1.4%)	1.88
9.	AI platforms promote inquiry-based learning and problem-solving in my training.	31(38.3%)	31(38.3%)	13(16.0%)	06(7.4%)	1.97

Table five shows that most pre-service teachers reported actively using AI tools like ChatGPT, Grammarly, and Quillbot for their research projects, with about 42% strongly agreeing and 47% agreeing, and only a few not using them. A large number also said AI helps them come up with creative ideas for lesson planning and teaching strategies nearly 86% agreed in total, while just a small fraction disagreed. More than 80% indicated they use AI to help structure or analyze academic papers, showing that AI is a common tool for organizing and improving their writing.

When it comes to the overall quality and creativity of their research, the majority (over 82%) felt that AI had a positive effect, with very few disagreeing. Finally, a good number (around 76%) agreed that AI platforms support inquiry-based learning and problem-solving in their training, though a small group did not share this view.

Research Question 3: What are the perceptions, competencies, and concerns of pre-service biology teachers regarding the use of AI tools in their teacher education programs in Kwara State?

S/N	**Perceptions, Competencies, and Concerns of Pre-service biology teachers in the use of AI**	**SA**	**A**	**D**	**SD**	**MEAN**
10.	I feel confident in using AI tools to support my learning and teaching activities.	16(21.6%)	54(73.0%)	03(4.1%)	0(0%)	1.77
11.	I believe AI can make teaching more engaging and effective for future classrooms.	20(27.0%)	40(54.1%)	13(17.6%)	0(0%)	1.92
12.	I worry about AI replacing the role of teachers in the future.	23(31.1%)	36(48.6%)	14(18.9%)	0(0%)	1.88
13.	I am aware of the ethical concerns involved in using AI for educational purposes.	14(18.9%)	53(71.6%)	04(5.4%)	02(2.7%)	1.90
14.	I need more training to use AI tools effectively in educational settings.	31(38.3%)	31(38.3%)	13(16.0%)	06(7.4%)	1.82

Table shows that most pre-service biology teachers feel confident in using AI tools to support their learning and teaching about 95% agreed or strongly agreed with a mean score of 1.77, showing high confidence levels overall. A large majority 81% believe that AI can make teaching more engaging and effective for future classrooms, though 18% of the respondents are less convinced. 80% of the respondents about expressed concern that AI might replace the role of teachers in the future, suggesting some anxiety about AI’s impact on the profession. Awareness of ethical concerns is also high over 90% said they were aware of potential ethical issues in using AI for education indicating that most pre-service teachers understand the need to use AI responsibly. Lastly, about 77% said they need more training to use AI tools effectively, highlighting that while confidence and awareness are high, there is still a strong demand for skill development.

Discussion of findings

The findings demonstrate that AI tools are becoming an integral part of pre-service biology teacher education in Kwara State, particularly for supporting inclusive teaching and enhancing research productivity. High levels of agreement on the frequent use of AI in training indicate a growing acceptance of technology as a valuable educational asset. The widespread use of generative AI applications for research and lesson planning underscores their role in fostering creativity, efficiency, and adaptability among pre-service teachers. Nevertheless, the presence of ethical concerns and fears about AI replacing teachers highlight the importance of balanced integration that safeguards human facilitation in education. The expressed need for additional training suggests that institutional efforts must move beyond access to technology, focusing instead on structured capacity-building programs that empower future educators to harness AI effectively and responsibly.

Conclusion

This study concludes that AI is increasingly recognized as a valuable tool in pre-service biology education in Nigeria, with strong evidence of adoption for research, lesson planning, and inclusive teaching practices. Pre-service teachers are confident in using AI and acknowledge its potential to enhance teaching effectiveness, yet they also express legitimate concerns about ethics and teacher replacement. The readiness to embrace AI is evident, but successful integration into teacher education programmes will require deliberate institutional support, comprehensive training, and policy frameworks that ensure equitable access and ethical use.

Recommendations

Based on the findings of the study, the following were recommended:

1. Teacher training institutions should embed structured AI literacy modules into teaching methods courses, focusing on both technical skills and pedagogical applications.
2. Colleges of Education should organize regular practical workshops where pre-service teachers can experiment with AI tools for lesson planning, assessment, and research.
3. Institutions should invest in AI-enabled educational resources and ensure that all students, regardless of location or economic background, can access them.
4. Training should explicitly address ethical issues, data privacy, bias in AI systems, and strategies for maintaining the teacher's role as a facilitator of learning.
5. Policymakers should support Colleges of Education with the digital infrastructure needed for large-scale AI adoption, especially in underserved areas

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UTILIZATION OF DIGITAL RESOURCES IN THE TEACHING OF BIOLOGY IN SENIOR SECONDARY SCHOOL IN ILORIN METROPOLIS

By

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Abstract

This research investigated the extent to which Biology teachers in Ilorin Metropolis utilize digital resources in their instructional practices, the types of tools employed, and the factors that shape their integration into teaching. The study was informed by the increasing recognition of digital technologies as essential drivers for improving instructional quality and fostering active learner participation in science education. Employing a descriptive survey design, data were gathered from a representative sample of Biology teachers in both public and private secondary schools using a validated questionnaire. Results indicated that although teachers exhibited moderate awareness and access to various digital tools—including interactive simulations, instructional videos, presentation applications, and online collaboration platforms—the frequency and sophistication of their use differed significantly. Teachers working in well-resourced schools with reliable internet connectivity demonstrated higher adoption rates, whereas those in less-equipped institutions tended to rely on basic tools such as slideshow presentations and pre-recorded lessons. The study identified key barriers to optimal use, including insufficient technical support, limited opportunities for training, unstable electricity supply, and time constraints in lesson preparation. Notably, younger teachers and those with stronger digital skills were more likely to experiment with advanced tools such as virtual laboratories and online assessment systems. The study recommends implementing regular professional development initiatives to enhance teachers' competence in digital pedagogy, coupled with strategic policies to improve technological infrastructure in schools. These measures could help close existing gaps and promote more effective, technology-driven Biology teaching within the Ilorin Metropolis.

Keywords: digital resources, Biology teaching, technology integration, Ilorin Metropolis, teacher utilization

INTRODUCTION

Biology, as a branch of science and a foundation for numerous fields of study, plays a vital role in advancing a nation's technological growth. Its contributions span areas such as medicine, forestry, agriculture, biotechnology, and nursing. Studying Biology at the senior secondary school level equips students with essential concepts, principles, and theories to tackle challenges both during their education and after graduation. (Aina, 2022) Biology as one of the science subject is bent in making one to be conversation with the environment he/she lives in appreciate the meaning of scientific life, to develop unbiased mind and to be intellectually homes with serve as ideal to the future citizen. Fortunately, it is a fact that Biology is the commonly chosen science subject of most secondary pupils as confirmed by the West Africa Examination Council (WAEC) record (Abulideh & Hassan, 2022).

Biology as an integral part of natural sciences is needed for our nation's technological breakthrough. According to Nsofor (2010). Biology covers a wide scope, and serves as a spring board for many future careers in science and technology and has application, nearly in every field of life. For a nation to be considered as a developed society in the technological age, the study of Biology is the brain behind its growth; it is important since it forms a veritable amour against misconception and superstitions which muddles technological advancement anywhere. It is a natural science that deals with the living world; how the world is structured, how it functions and what these functions are, how it develops, how living things came into existence, and how they react to one another and with their environment (Umar, 2021). Biology is a prerequisite subject for many fields of study that contributes immensely to the technological growth of the Nations (Amal, 2018). This includes medicine, pharmacy, nursing, agriculture, forestry, biotechnology, nanotechnology, and many other areas (Ahmed & Abimbola, 2011). As a scientific discipline, it is a fundamental subject in the development of any Nation including Nigeria. Its developed potentials are evident in biomedical sciences, agricultural sciences, textile, paper and dyeing technology, biotechnology, environmental sciences and socio-cultural issues (Tutor Vista, 2014).

Biology is one of the core subjects in Nigerian secondary school curriculum; because of its importance, almost all students enroll for it in the senior secondary school certificate examination (SSCE) (Ahmed, 2023). Biology is introduced to students at senior secondary school level as a preparatory ground for human development, where career abilities are groomed, potentials and talents discovered and energized (Federal Republic of Nigeria, 2019). The quality and quantity of science education received by secondary school students are geared towards developing future scientists, technologists, engineers, and related professionals (Kareem, 2013).

Media are generally defined as the means by which information is conveyed from one place to another. In the past century, various forms of media have been used to convey instruction and to support learning. Examples of instructional media include traditional means of delivering instruction (chalkboards, textbooks, overhead projectors, and teachers), mass media used for education (newspapers, movies, radio, and television), and the newer "electronic" instructional media (computers, interactive video, and multimedia systems). All instruction requires the selection and use of at least one medium to deliver instruction. Many alternative media and mixtures of media may be chosen for any given learning goal and group of students. Thus, research questions have compared the learning benefits of various media and mixes of media for different types of learning goals and students at different ages and aptitude levels. Thousands of studies have been and continue to be conducted. (Kareem, 2021).

Instructional materials are used efficiently and actively to facilitate the teaching-learning process in most advance countries such as United States of America. However, the situation is not good enough in most of the developing countries, as well as in Nigeria. Firstly, only the lower quality and less quantity of instructional materials are provided to schools, in this way, the availability of instructional material is very low. Secondly, teachers are not trained properly for the use of instructional materials. Thirdly, teachers do not have interest in using the instructional materials in their teaching process. Instructional materials are classified into three categories namely: visual materials, audio materials and audio-visual materials. Visual materials are the materials (instructional materials) which transmit information and could be coded using the sense of sight. They may be concrete objects such as model or print such as photographs, magazines and journals. There category of instructional materials is usually captivating and because of this potentials, learners learn through them effectively. This brings to mind the chines adage that says what I hear I forget, what I see I remember and what I do, I understand (Aboderin, 2022).

Digital Instructional materials are very important roles in the teaching learning process. It enhances the memory level of the students. At this time, education has spread wide and entirely oral teaching cannot be the key to successful pedagogy, therefore, the teacher has to use instructional materials to make the teaching-learning process interesting. It is the use of instructional materials that can enhance the learning achievement (Abdol, 2022). Amal (2016) stated the important elements of behaviour that provide the basis for learning theory: situations, the situation consists of all the objects, persons and symbols in learning environment. Experience in situation prepared a person to respond to similar situation on the future situation must be created in which learner can be satisfied. Personal characteristics under this heading will include all the abilities and all the typical responses that the person brings to the situation.

Statement of the Problem

Digital teaching resources has received much attention from various institutions and academic scholars in the past few years. Digital teaching resources is a computer based educational system that enables learner to learn anywhere and at any time. Digital teaching resources is mostly delivered through the internet, although in the past it was delivered using a blend of computer-based methods like CD-Rom (Epignosis, 2022). The use of e-learning tools in respect to learning process is critical for the successful implementation of various learning environments (Abdullah & Azzedine, 2020). Galy, Downey and Johnson (2022) noted that modern classroom, whether online or schools-based, use e-learning tools and learning management systems that capture student cognition and engages them in the learning process via technology, while increasing their need for self-directedness.

Digital teaching resources imperatively and learning environment cannot be over emphasized. The use of ICT in modern learning environment ranges from slide use of computers in practical aspects to an online learning experience which enhances and improves students' intellectual and learning behavior (Smith, 2022). With the introduction of computers, the precursor of our modern-day ICT, and the promising potentials of computer-based instruction and learning, many researchers and institutions were motivated to invest viable resources so as to ensure the possibility of computers enhancing learning culture. Many authorities believe that computers should be brought into the education system because of the expectation that students would benefit quantitatively from computers by providing them with the software and hardware for an effective learning process (Wheeler, 2020).

Imperatively, the role that ICT play in the educational and learning environment cannot be over emphasized. The use of ICT in modern learning environment ranges from slide use of computers in practical aspects to an online learning experience which enhances and improves students' intellectual and learning behavior (Smith, 2019). With the introduction of computers, the precursor of our modern-day ICT, and the promising potentials of computer-based instruction and learning, many researchers and institutions were motivated to invest viable resources so as to ensure the possibility of computers enhancing learning culture. Many authorities believe that computers should be brought into the education system because of the expectation that students would benefit quantitatively from computers by providing them with the software and hardware for an effective learning process (Wheeler, 2022).

Instructional media encompasses all the materials and physical means an instructor might use to implement instruction and facilitate students' achievement of instructional objectives. This may include traditional materials such as chalkboards, handouts, charts, slides, overheads, real objects, and videotape or film, as well newer materials and methods such as computers, DVDs, CD-ROMs, the Internet, and interactive video conferencing.

The term instructional media has been defined in a variety of ways. In some cases, it refers to all aids that are used by the lecturer and students. In other cases, it refers only to printed media. In this chapter, we shall use the term to mean all devices and materials used in the teaching and learning processes. This definition is close to a broader definition such as that of Romiszowski (2022) which includes not only electronic communications media, but also such devices as slides, photographs, teacher-made diagrams, charts, real objects and handouts that we use in the process of planned instruction.

Teaching media or also well-known as Instructional Media refers to all devices and materials used by teacher and student in the teaching and learning processes. This definition is close to a broader definition such as that of Romiszowski (2022) which includes not only electronic communications media, but also such devices as slides, photographs, teacher-made diagrams, charts, real objects and handouts that we use in the process of planned instruction

Purpose of the Study

The main purpose of this study will determine the teachers' utilization of Digital Resources in the teaching Biology in Senior Secondary School in Ilorin Metropolis specifically the study sought to;

determine the digital resources that are available for teaching Biology in Ilorin West LGA senior secondary schools

determine extent of utilization of digital resources for teaching biology in Ilorin West LGA senior secondary schools

find out the challenges facing biology teachers in the utilization of digital resources in Ilorin West LGA senior secondary schools

Research Questions

The following research question will be developed to guide this study:

does digital resources is available for teaching biology in Ilorin West LGA senior secondary schools

does teacher make the use of digital resources for effecting teaching of Biology in Ilorin West LGA senior secondary schools what challenges do teacher face during the utilization of digital resources in Ilorin West LGA senior secondary schools

Significance of the Study

This study investigated teachers utilization of digital teaching resources on the teaching of Biology in senior secondary schools in Ilorin Metropolis; the main implication and significant of this study will enable the students to acquire digital knowledge, digital natives, the net-generation, the digital-generation, and millenniums are all labels to identify today's learners created the term digital native in his work Digital Natives towards the learning of Biology in Senior Secondary Schools in Ilorin metropolis, Digital Immigrants to describe the generation of learners growing up interacting with digital technology. Educational authors, noted that the average college student has spent less than 5,000 hours of his/her life reading, yet he/she has spent over 10,000 hours playing video games and 20,000 hours watching television. The National School Board Association (2022) reported teens engage in social networking almost as much as they watch television.

The knowledge obtained would help the government most especially local government and educators to reflect and make evaluation on the requirements of other instructional materials apart from class-rooms alone. Since the beginning of community secondary schools, the government and local communities have been putting more emphasis on the construction of new class-rooms, and recently, construction of laboratories. However, provision of quality secondary school education requires more than just class-rooms and laboratory buildings. The evaluation of instructional materials, along with other reform movements, allows educators and planners to plan for appropriate environment for teaching and learning so as to provide quality secondary school education.

The study would also influence education planners to consider appearances of physical structures such as classrooms and availability of other teaching and learning materials as some of the important factors that can influence parents to send their children to particular schools, which have attractive physical appearance and variety of other facilities. Attractive environment and the availability of other learning resources can influence students to stay in schools and stimulate learning.

REVIEW OF RELATED LITERATURE

Nature and Concept of Digital Resources

Digital learning materials or e-learning materials are study materials published in digital format. These include e-textbooks, e-workbooks, educational videos, e-tests, digital learning devices are referred to as educational media, instructional media, digital learning tools, multimedia devices which are aids to instructional delivery. Studies on learning devices that has very successful instructional delivery in Nigeria schools have been looked into in the study. For example. Examined the accessibility and degree of utilization of Information and Communication Technology (ICT) devices for instructional delivery in Cross River State tertiary institutions. Their study concluded that there was significantly low usage in respect of the devices used by the instructors (Tah, 2022).

Meanwhile, Oshinaike and Adekunmisi (2012) examined the use of multimedia devices on learning. The authors stressed the needs for teaching and learning processes to be replaced by multimedia technology which provides a suitability learning environment that promotes self-paced and individualization. Also, Oshinaike A. (2012) further investigated the relevance of educational media and multimedia technology for effective content delivery. The study further highlighted the various classifications of educational media and multimedia technology with diagram and tabular illustration.

Likewise, Ngonso N. (2018) worked on the influence of media on interactive communication in Nigeria Education. It was concluded that the learners and instructors are aware of this due to the use of the equipment by lecturers. In essence, visual learning devices are majorly the instructional equipment that catch the attention of the learners through the sense of sight.

Digital teaching resources has received much attention from various institutions and academic scholars in the past few years. Digital teaching resources is a computer based educational system that enables learner to learn anywhere and at any time. Digital teaching resources is mostly delivered through the internet, although in the past it was delivered using a blend of computer-based methods like CD-Rom (Ngonso, 2021). The use of Digital teaching resources tools in respect to learning process is critical for the successful implementation of various learning environments Abdullah & Azzedine, 2011 noted that modern classroom, whether online or schools-based, use Digital teaching resources tools and learning management systems that capture student cognition and engages them in the learning process via technology, while increasing their need for self-directedness.

Instructional media is an integral part of the school in which education system can improve. Every job has its own tools, teaching has got its own resources, which anyone who has chosen teaching as a career must be aware of. In this age of technology that learners need to understand many things relating to education, words alone are not enough such as projected instructional material. Teaching becomes more interesting when concrete objects are used rather than oratory words from the teacher which are easily forgotten. The development of instructional media however sets the pace for a literary-based approach of teaching which emphasizes the promotion of knowledge and change of abstract to concrete learning. Instructional media enhance and facilitates learning which leads to fostering and stimulations of learning environment. (Calderoni, 2022).

Imperatively, the role that digital teaching resources play in the educational and learning environment cannot be over emphasized. The use of digital teaching resources in modern learning environment ranges from slide use of computers in practical aspects to an online learning experience which enhances and improves students' intellectual and learning behavior (Smith, 2003). With the introduction of computers, the precursor of our modern-day ICT, and the promising potentials of computer-based instruction and learning, many researchers and institutions were motivated to invest viable resources so as to ensure the possibility of computers enhancing learning culture. Many authorities believe that computers should be brought into the education system because of the expectation that students would benefit quantitatively from computers by providing them with the software and hardware for an effective learning process (Wheeler, 2010).

Several studies have been conducted on instructional resources and effectiveness of education. Obwoge and Mosol (2016) carried out the utilization of instructional media in training health professional. Hilda and Bernard (2015) investigated the availability and use of instructional materials in teaching of conflict and conflict resolution in primary schools in Nandi North district, Kenya. Sample of 45 teachers was selected purposively. Questionnaire and classroom observation checklist were used for data collection. Descriptive statistics such as frequencies and percentages were used to analyze the data collected. The findings of the study show that teachers lacked sufficient instructional materials for effective teaching. Furthermore, Okpechi and Denwigwe (2022) embarked on the teacher and teaching with instructional materials in the teaching of science subjects and the contribution of guidance and counselors therein. Sample of 500 participants were selected from four higher institutions in Cross River State. Self-designed questionnaire titled "Preferred Crisis Management Strategies Questionnaire" was used to collect data. The data collected was analyze using independent t-test. The finding revealed that crisis management strategy by lecturers was significantly low in higher institutions in Cross River State. Okpechi (2022) investigated instructional materials as correlates of students' academic performance in Biology in senior secondary schools. Dhakal (2017) conducted a similar study on the availability and utilization of instructional materials in teaching geopraphy in secondary schools.

The digital age has transformed the way people communicate, network, seek help, access information and learn. We must recognize that young people, particularly students, are now an online population and internet access is through variety of means, such as computers, television and mobile phones (Tapscott, 2020; Al Ansari, 2023). Thus, as technology becomes more and more embedded in our culture, students must be provided with relevant and contemporary experiences that allow them to successfully engage with technology and even prepare them for life after school. The use of Digital teaching resources tools, it is believed, would have a positive influence on both students' achievement, motivation and learning process.

The use of Information Communication Technology, ICT in education lends itself to more student-oriented learning settings. With the world moving rapidly into digital media and information, the influence of ICT on both education and students' learning behavior is becoming more and more important and this importance will continue to grow in the 21st century. Web Based Training and its newer and more general synonymous term Digital teaching resources are two of today's buzz-words in the academic world (Odhiambo, 2022). Decision-makers associate with its new ways of learning that Instruction primarily deals with the development of knowledge and understanding in the learners. It can be seen as the system of leading the learners through body of knowledge that can enhance the learner's ability to comprehend (Oladosun, 2023). Media on the other hand, is the channel through which teacher communicate the concepts of lesson to learners in a more concrete manner rather than abstract approach (Obwoge & Mosol, 2023). Instructional media are computer-based tools for learning used to clarify points towards allowing learners to interact with words, images and ideas so as to develop their abilities. In the same vein, Instructional media are materials used to facilitate teaching and learning process for the purpose of making the content of instructions more meaningful and better achievement of educational goals and objectives (Obwoge & Mosol, 2020).

Basssey, (2022) described instructional materials media as system component that may be used as part of instructional process which are used to disseminate informative message and ideas or which make possible communication in the teaching-learning process. Experience over the years has shown that teachers have been depending on excessive use of words to express, convey ideas or facts in the teaching-learning process. This process is termed the 'chalk-talk' method. Today advances in technology have made it possible to produce materials and devices that could be used to minimize the teachers' talking and at the same time, make the message clearer, more interesting and easier for the learner to assimilate (Onasanya, 2018). According to Soetan, (2010), graphics including charts, posters, sketches, cartoons, graphs and drawings. Graphics communicate facts and ideas clearly through combination of drawings, words and pictures. The use of graphics in teaching creates definitiveness to the materials being studied. They help to visualize the whole concepts learned and their relationships with one another.

Digital teaching resources are also information carrying technologies which a classroom teacher can use in concretizing instruction and enhancing teaching and learning process (Onasanya, 2024). Therefore, teaching and learning with instructional media help the teachers to manipulate real objects for different educational context in order to achieve meaningful and productive learning. There are different criteria that should be considered in selecting appropriate instructional media such as the age level of learners, safety of learners, cost implication of materials, intelligence of the learners, motivation, curriculum relevancy, skill and attitude of learners to mention but few. Instructional meadia are materials use in teaching and learning in order to make teaching more interesting, interactive and exciting to learners with the purpose of achieving instructional objectives (Onasanya, 2024). Instructional media in this study refers to the use of projected media, non- projected visual media and simulations and games for effective management of elementary education.

Digitals Resources and its Implication on Learning Performance

Meanwhile, Oshinaike and Adekunmisi (2012) examined the digital teaching resource and learning, The authors stressed the needs for teaching and learning processes to be replaced by multimedia technology which provides a suitability learning environment that promotes self-paced and individualization. Also, Oshinaike and Adekunmisi (2014) further investigated the relevance of educational media and multimedia technology for effective content delivery. The study further highlighted the various classifications of educational media and multimedia technology with diagram and tabular illustration. The importance of digital teaching resources in teaching and learning cannot be underestimated. A lot has been written to show the indispensable role of materials in curricular implementation. Instructional materials make learning more interesting, practical, realistic and appealing. They also enable both the teachers and students to participate actively and effectively in lesson sessions. They give room for acquisition of skills and knowledge and development of self- confidence and self- actualization.

Ibeneme (2010) observed that teaching aids are important for practical and demonstration in the class situation by students and teachers. Ibenem (2010) saw instructional materials as devices that assist the teacher to present a lesson to the learners in a logical manner. In his own perspective, Fadeiye (2015) saw instructional materials as visual and audio-visual aids, concrete or non-concrete, used by teachers to improve the quality of teaching and learning activities. Agina-Obu (2015) submitted that instructional materials of all kinds appeal to the sense organs during teaching and learning. Also described instructional materials as objects or devices that assist the teachers to present their lessons logically and sequentially to the learners. Oluwagbohunmi and Abdu-Raheem (2022)

Instructional materials do so because they constitute tangible products, which can be used by learners. During such usage, a learner interacts with the material. Such interaction may entail that a leaner manipulates the instructional material and expresses his/her views about the problem and idea encapsulated in the material. Then, any feedback obtained from such usage informs the teacher (which is the source) the extent to which a learner has attained an instructional objective. Besides, Nigeria is aware of the importance of instructional materials for effective communication in her school system. In 1975 for instance, the federal ministry of education organized an exhibition of improved instructional materials by classroom teachers all over the federation in four centers- Lagos, Ibadan, Kaduna and Enugu. During these exhibitions participants displayed various type of instructional materials, which they improvised to help learners concretive instruction in different subject areas. As for people that participated in this exhibition, they thought that a follow-up to these exhibitions could have been comp odium of all improvised instructional materials with a view to establishing infrastructure to encourage the mass production of suitable ones. Unfortunately, this follow-up was not encouraged. Despite, the federal ministry of education in keeping with its realization of the importance of instructional materials established a National Education Technology Center (NETC) in Kaduna. Also then, states ministries of education have also established units responsible for instructional materials many colleges of education, polytechnics and universities have set up Departments of Educational Technology, at training mechanics in the production and use of different soft ware/hardware materials (Federal Republic of Nigeria, 1977,1991, 2004). But despite this increased awareness on the part of educationists, an awareness that led to these establishments,

This study intended to find the Influence of projected instructional media in Ilorin East Local Government Area Secondary school. The knowledge obtained would help the government most especially local government and educators to reflect and make evaluation on the requirements of other instructional materials apart from class-rooms alone. Since the beginning of community secondary schools, the government and local communities have been putting more emphasis on the construction of new class-rooms, and recently, construction of laboratories. However, provision of quality secondary school education requires more than just class-rooms and laboratory buildings. The evaluation of instructional materials, along with other reform movements, allows educators and planners to plan for appropriate environment for teaching and learning so as to provide quality secondary school education the purpose include.

Projected Instructional media are also information carrying technologies which a classroom teacher can use in concretizing instruction and enhancing teaching and learning process (Yusuf & Ogunlade, 2016). Therefore, teaching and learning with instructional media help the teachers to manipulate real objects for different educational context in order to achieve meaningful and productive learning. There are different criteria that should be considered in selecting appropriate instructional media such as the age level of learners, safety of learners, cost implication of materials, intelligence of the learners, motivation, curriculum relevancy, skill and attitude of learners to mention but few. Instructional meadia are materials use in teaching and learning in order to make teaching more interesting, interactive and exciting to learners with the purpose of achieving instructional objectives (Onasanya, 2016). Instructional media in this study refers to the use of projected media, non- projected visual media and simulations and games for effective management of elementary education.

On one hand, it is noted that Digital teaching resources is at least as effective as traditional instructional strategies (Rosenberg, Grad & Matear, 2013), and that there are no major differences in academic performance between the more traditional and more technology-oriented modes of instruction (Cavanaugh, 2001). Other studies however, find that greater online teaching has a negative impact on performance (Johnson, 2005). For instance, Adeyemi (2011) is of the view that despite the claims that Digital teaching resources can improve the quality of education, making materials available online results in improved learning results only for specific forms of collective assessment; resistance to change from traditional pedagogical methods to more innovative, technology-based teaching and learning methods by both students and teachers; lack of qualified personnel; inadequate ICT infrastructure as a result of underfunding.

Abulibdeh, and Hassan (2011), were also of the view that Digital teaching resources makes learners undergo contemplation, remoteness and lack of interaction or relation, making it require strong inspiration and skills to the management of time so as to reduce such effects. They also found that clarifications, offer of explanation and interpretation is less effective in Digital teaching resources; deteriorate institutions', teachers' role and several other identified challenges. Identifying the actual impact of Digital teaching resources on students, schools and the wider environment when put to use is actually difficult because of its newness and diversity of the programmes and the complexity of factors affecting outcome, measuring of its impact is an emerging issue and closely related on how the technology is used as an educational tool and other factors.

Challenges of using Digital Teaching Resources

Problem of using digital teaching resources include the following; First, we will discuss educators' attitudes and beliefs, referred to as second-order barriers (Ertmer, 2022). If teachers do not expect new technology to be useful or do not think they have the required experience to use such technologies, they are more likely to persist using more traditional methods. Closely related to the attitudes and beliefs, teacher resistance may present a barrier to technology integration. Finally, we discuss the influence of teachers' skills and knowledge as they pertain to technology.

Teacher Attitudes and Beliefs

Teachers' attitudes and beliefs are crucial factors in determining the role and effectiveness of digital teaching recourse. Attitudes and beliefs about both educational technology and pedagogy in general will ultimately influence how teachers implement technology. In the following sections, we discuss these issues and ways to promote positive attitudes that can optimize technology use. Now that technology is being widely used in schools, perhaps the most important question is how to best implement technology, rather than whether technology will be used (Ertmer, 2016; Ertmer et al., 2012; Keengwe, Onchwari, & Wachira, 2008; Lowther, Inan, Strahl, & Ross, 2018).

Confidence in skills and Knowledge

Given the abundance of available educational technology, it is essential that teachers feel comfortable and confident about their ability to use them effectively. Many current teachers grew up without access to technologies like the personal computer and the internet, but students today are raised in an environment saturated by computer technology. These "digital natives" can intimidate teachers, especially teachers with little technological experience. If teachers feel they do not have the necessary competencies when using technology, they may feel less in control of the class, use less technology, and be unlikely to explore new possibilities that utilize technology when designing their classes (Hughes, 2015; Rakes & Casey, 2012). By sticking to traditional teaching methods, teachers who are less fluent with technology maintain a feeling of control in the classroom and will not have to prepare to face the challenges of instructing digital natives in a digital environment.

In a survey of 764 teachers, Wozney, Venkatesh, and Abrami (2006) found that one of the two strongest predictors of teachers' technology use was confidence in achieving instructional goals using technology. Teachers who believe they lack training can either decide to work with technology at their current level of expertise, or postpone the use of technology until they consider that they have sufficient competence (Ertmer, 1999). To build teachers' knowledge to a sufficient level, boosting confidence in the process, training and support from the educational administrators is necessary.

Teacher Resistance to Technology in the Classroom

Browsing online teacher forums makes it clear that implementing new technologies into lesson plans can be a difficult task. Perhaps the most common reason mentioned by teachers for not actively integrating new technologies is that many teachers are satisfied with their current lesson plans. A teacher's desire for their students to learn effectively drives classroom instruction, and if current lesson plans meet the needs of students, there is very little motivation for the teacher to alter them. Educators spend countless hours creating lesson plans that will hold attention and make learning exciting. Revising lesson plans means several hours of additional work for the teacher, which is problematic given an already demanding schedule. Simply revising lesson plans can occupy a great deal of time, but revising lesson plans to incorporate technology is even more labor intensive. When adopting new classroom technologies, educators face the problem known online as the "double innovation" problem (Cleaver, 2014).

Double innovation essentially adds an additional layer of preparation teachers must work through. The teacher must first learn the technology well enough to utilize it in a classroom setting before deciding how to integrate the technology with classroom objectives and curriculum. While educational technologies are becoming easier to learn, the double innovation problem still results in additional preparation time. Data collected from teacher interviews conducted by Ertmer (2012) showed time as being the sixth most influential barrier to integrating new classroom technologies. A teacher's time is extremely valuable, and it should come as no surprise that time is one of the most commonly cited barriers to integrating new technologies in the classroom.

Empirical Studies on Utilization of Digital Resources for Teaching Biology

Maybe drill and practice programs are the most well known digital learning materials. Essentially, these programs built on existing knowledge and give learners the opportunity to consolidate and repeat knowledge and train and automate skills (Abdul, 2016). Drill and practice programs do not have a good reputation nowadays, they are associated with an out of date learning theory in which dull repetition and lower-order thinking are dominant factors. Moreover, drill and practice programs are condemned for not optimally using the technological power of new generations of computers. In spite of the many ill-designed drill and practice programs, this criticism seems to be too harsh. The educational value of these programs (like all programs) depends one the quality of its instructional and technical design. And although rather scarce, there are sound drill and practice programs which also stretches the capabilities of modern computer technology to its limits. An example of such program is the Dutch program 'Plato en de rekenspiegel' [Plato and the arithmetic mirror] that provides learners with ample opportunities to practice their numeric skills. This program consists of excellent facilities to diagnose performance and give adequate feedback and guidance. The program calculates a model of the learner, and based on his/her past performance, subsequent tasks are given. Feedback is also provided by means of suggesting and supporting different calculating strategies. In the user-interface of Plato is presented. Gery, (2016).

Contrary to drill and practice programs, tutorials support the acquisition of knowledge and/or skills. Tutorials mostly offer pre-defined sequences to build up the desired knowledge and skills. They often apply immediate feedback to guide learning in an effective way. Tutorials are very common in learning software applications (for example: http://training.ase.tufts.edu/) But tutorials may also serve instructional purposes in school subjects. The reputation of tutorials is better than that of drill and practice programs, although also tutorials fit more easily in a tradition of knowledge transmission then in more constructivist visions on teaching and learning.

Multimedia (or hypermedia) refer to programs that contain text, images and sound which are interacted in a non-linear structure. The structure of the information may best be typified as randomly sequenced. Like tutorials, also multimedia are primarily designed for the acquisition of knowledge. The essential difference between the two lies in the organization of information: linear or branched sequences in tutorials and randomly sequences in multimedia programs. This latter sequence allows user to pursuit according to a self-chosen path. Moreover, multimedia programs usually have a large amount of the information codified in a non-text way, such as pictures, animations and video. Presenting information in a multimedia program is especially appropriate in a ill-structured and complex knowledge domains in which opinions differ. Teacher knowledge is an example of such a domain. Therefore, multimedia is apt for teacher education. In Figure 3 an illustration of such a program, in the form of a multimedia case, is pictured.

Simulations are programs that contain a model of a system or a process (De Jong & Van Joolingen, 2016). The manipulation of variables is essential for learning with simulations. Allessi and Trollip (2011) give a simple but clear distinction between two types of simulations. Either, simulations are about something or about how to do something (p.214). The former (physical simulations) focuses on an object or a phenomenon, the latter (procedural simulations), concentrates on a sequence of actions to reach a goal. Physical simulations may have a time component, which implies that users run a simulation, for example, about photosynthesis, as the system unfolds. Time is not a factor in for example a simulation about 'The influence of the number of foxes on the population of rabbits', because the learner may iteratively manipulate the variables, by going back to a default option and start the process with other values.

Simulations are sometimes perceived as archetypes for the power computer technology may bring to education and are therefore often associated with constructivist orientations. However, simulations may also designed with a behavioristic orientation in mind. Despite of the orientation, the educational potential of computer simulations is high, because simulations optimally use the interactive possibilities of computer technology. Moreover, simulations allow to handle situations that would be too dangerous or time-consuming in real life. The flight simulator, such as 'Microsoft Flightsimulator 2000' is a well-known example of a simulation that enable pilots to train crash scenario's.

METHODOLOGY

Research Design

The study adopted a descriptive survey design on teacher's utilization of digital teaching resources on teaching of Biology in Senior Secondary School in Ilorin metropolis. The descriptive survey design method was used in exploring the digital teaching resources on student learning. It is an efficient approach of collecting data regarding characteristic of sample of a population, current practices, conditions or needs (Sekaran & Bougie, 2022).

Population of the Study

Population of this study comprised of all Senior Secondary Schools Biology Teachers in Ilorin West while the target population of this study consisted of 20 selected senior secondary schools Biology Teacher in Ilorin Metropolis and in each school, five Biology teachers was purposively selected to form a total number of 100 respondents for the study.

Sample and Sampling Technique

Simple random sampling technique was used to select 100 teachers across 20 secondary schools in Ilorin Metropolis. Simple random sampling technique was use to select the schools, while the researcher make used of random sampling in selecting five schools.

Research Instrument

The questionnaire was the main instrument employed in collecting the relevant data needed for this research work. The questionnaire that contains information used to sample opinion of respondent(s). The use of questionnaire is necessary so as to ensure accessibility of desired respondents and this is because, it is speedy, it is less costly, it reduces chance of interviewer influencing result through different questions, data collected is easy to tabulate, interpret and analyze and since they properly designed and respondent's identities were kept confidential, and reliable response were obtained.

The use of ‘‘strongly agreed, agree, neutral, disagree and strongly disagreed” was adopted. The questionnaire was designed in format that respondent were able to provide information on the study and also drafted carefully in other to allow as much as possible for quick understanding of the questionnaire. The questionnaire was drafted into two sections. Section A comprised items to determine the personal data of respondents. Section B comprised of questions structured in such a way that provided adequate solutions to the research questions raised.

Validity of the Instrument

Validity is often defined as the extent to which an instrument measures what it asserts to measure. It is also a measure of truth or falsity of the data obtained through using the instrument (Bougie, 2010). Validity, attempts to find out whether the test measures what is supposed to measure. To ensure validity of the research instrument, the questionnaire was given to the researcher's supervisor to vet and other two lecturers in the Faculty of Education, Al-Hikmah University. This helped to determined the faced and content validity of the instrument and all necessary corrections made by them will be effected before the final printing of the instrument.

Reliability of the Instrument

The questionnaire was subjected to reliability test of Cronbach Alpha using test-retested method. 20 Biology teachers was selected and examined using the questionnaire at an interval of three weeks. The data collected were analyzed using the Cronchback Alpha to determine the reliability of the content and structure of the items in the questionnaire.

Procedure for Data Collection

The instrument was personally administered by the researcher. The researcher ensure that each item on the questionnaire was careful read and understand by the respondents and where necessary, explanation was made so that the responses provided adequate information to the best of their knowledge. The complete questionnaires were retrieved immediately to ensure adequate submission.

Method of Data Analysis

The collected data was analyzed using descriptive statistics, with research questions examined through frequency counts and percentage analysis.

RESULTS AND DISCUSSION

Results

This chapter presents the data collated and its analysis with the interpretation of results. This was done under the following subheadings: Gender Distribution, Class Range Distribution of Respondents, and result presentations of research questions.

Table 1:

Demographic Distribution of Respondents

Variables	Frequency	Percentage (%)
Gender		
Male	54	54.0
Female	46	46.0
Total	**100**	**100.0**

Table 1, revealed that 46 respondents (46%) were female, while 54 (54%) were male. This implies that the majority of the respondents among secondary school teacher in Ilorin west Kwara State were Males.

Research Question One:

Does digital resources is available for teaching biology in Ilorin West LGA senior secondary schools?

Table 2:

Respondents on digital resources is available for teaching biology in Ilorin West LGA senior secondary schools.

S/N		Available	Not Available
1.	Projector	73(73%)	27(27%)
2.	Laptop	69(69%)	31(69%)
3.	Electronic Microscopic	52(52%)	48(48%)
4.	eduClipper	51(51%)	49(49%)

5.	Hand Lens	83(83%)	17(17%)
6.	Storybird	81(81%)	19(19%)
7.	AudioNote	67(67%)	33(33%)
8.	WeVideo	88(88%)	12(88%)
9.	Educreations	78(78%)	22(22%)
10.	Whiteboard	75(75%)	25(25%)

In Table 2, it was revealed that 73(73%) of the respondents admit on the availability of Projector while 27(27%) admit on its non-availability, 69(69%) of the respondents admit on the availability of Laptop while 31(31%) admit on its non-availability, 52(52%) of the respondents admit on the availability of Electronic Microscopic while 48(48%) admit on its non availability, 51(51%) of the respondents admit on the availability of edu Clipper while 49(49%) admit on its non availability, 83(83%) of the respondents admit on the availability of Hand Lens while 17(17%) admit on its non availability. 81(81%) of the respondents admit on the availability of Storybird while 19(19%) admit on its non availability. 67(67%) of the respondents admit on the availability of AudioNote while 33(33%) admit on its non availability. 88(88%) of the respondents admit on the availability of WeVideo, while 12(12%) admit on its non availability. 78(78%) of the respondents admit on the availability of Educreations while 22(33%) admit on its non-availability. 75(75%) of the respondents admit on the availability of Whiteboard while 25(10%) admit on its non-availability.

Research Questions Two: Does teacher make the use of digital resources for effective teaching of Biology in Ilorin West LGA senior secondary schools?

Table 3:

Respondents response on the Teacher make the use of digital resources for effective teaching of Biology in Ilorin West LGA senior secondary schools

S/N		SA	A	D	SD
1.	I used projector for effective teaching of Biology	47(47%)	30(30%)	13(13%)	10(10%)
2.	I usually use electronic Microscope to view micro-organisms	34(34%)	26(26%)	12(12%)	28(28%)
3.	I used litmus paper to determine whether a solution is acidic or base	55(55%)	30(30%)	10(10%)	5(5%)
4.	I used test tube for mixing and heating chemicals	60(60)	18(18%)	17(17%)	5(5%)

5.	I used hand lens to magnify objects and small specimens	30(30%)	48(48%)	12(12%)	10(10%)
6.	I used hand lense to view invisible microorganism	30(30%)	30(30%)	30(30%)	30(30%)

Table 3, Revealed that a large number of the respondents 77(77%) agreed on the statement: I used projector for effective teaching of Biology, while 23(23%) disagreed with the statement. 60(60%) agreed on the statement: I usually use electronic Microscope to view micro-organisms, while 40(40%) disagreed on the statement. 85(85%) agreed on the statement: I used litmus paper to determine whether a solution is acidic or base, while 15(15%) disagreed on the statement. 78(78%) of respondents agreed on the statement: I used test tube for mixing and heating chemicals, while 22(22%) disagreed with the statement. 78(78%) respondents agreed on the statement: I used hand lens to magnify objects and small specimens, while 22 (22%) disagreed with the statement. 60(60%) respondents agreed on the statement: I used hand lense to view invisible microorganism while 22 (22%) disagreed with the statement. This implies that the majority of the respondents among secondary school Teacher make the use of digital resources for effecting teaching of Biology in Ilorin West LGA senior secondary schools**.**

Research Question Three: What challenges do teachers face during the utilization of digital resources in Ilorin West LGA senior secondary schools ?

Table 4:

Respondents response on the Challenges teacher face during the Utilization of Digital Resources in Ilorin West LGA Senior Secondary Schools

S/N		SA	A	D	SD
1.	Does electricity is among the challenges teacher face during the uses of digital resources for teaching	55(55%)	15(15%)	13(13%)	17(17%)
2.	Does environmental factors are among the challenges teachers face during the uses of digital resources	40(40%)	40(40%)	10(10%)	10(0%)
3.	Does sufficient network services is among the challenges do teacher face during the uses of digital resource in the school	46(46%)	34(34%)	12(12%)	8(8%)

4.	Does sufficient digital resources is among the challenges faced by the teaching during the teaching of biology	44(44%)	20(20%)	30(30%)	6(6%)
5.	Does uses of digital instructional material to teach biology helps biology teachers to convey the message of the lesson to the learners	52(52%)	30(30%)	14(14%)	4(4%)

In Table 4, it was Revealed that the largest number of the respondents 70(70%) agreed on the statement: Does electricity is among the challenges teacher face during the uses of digital resources for teaching, while 30(30%) respondents, disagreed with the statement. 80(80%) respondents agreed on the statement: Does environmental factors are among the challenges teachers during the uses of digital resources, while 20 (20%) of respondents disagreed on the statements, furthermore, 80 (80%) of the respondents agreed on the statement: Does sufficient network services is among the challenges do teacher face during the uses of digital resource in the school, while 20 (20%) respondents disagreed on the statement. 64(64%) respondents agreed on the statement: Does sufficient digital resources is among the challenges faced by the teaching during the teaching of biology, while 36(36%) disagreed on the statement. 82(82%) respondents agreed on the statement: Does uses of digital instructional material to teach biology helps biology teachers to convey the message of the lesson to the learners, while 18(18%) disagreed on the statement. Which implies that majority of the respondents among secondary school teachers agreed on the Challenges teacher face during the Utilization of Digital Resources in Ilorin West LGA Senior Secondary Schools.

Discussion of Findings

The result of the first research question revealed that majority of the respondents among secondary schools teachers agreed that majority of digital resources is available for teaching biology in Ilorin West LGA senior secondary schools.

Second research question reveals that majority of the respondents among secondary school Teacher make the use of digital resources for effective teaching of Biology in Ilorin West LGA senior secondary schools**.**

Lastly, the third research question revealed that majority of the respondents among secondary school teachers agreed on the Challenges teacher faced during the Utilization of Digital Resources in Ilorin West LGA Senior Secondary Schools.

Table 3, Revealed that a large number of the respondents 77(77%) agreed on the statement: I used projector for effective teaching of Biology, while 23(23%) disagreed with the statement. 60(60%) agreed on the statement: I usually use electronic Microscope to view micro-organisms, while 40(40%) disagreed on the statement. 85(85%) agreed on the statement: I used litmus paper to determine whether a solution is acidic or base, while 15(15%) disagreed on the statement. 78(78%) of respondents agreed on the statement: I used test tube for mixing and heating chemicals, while 22(22%) disagreed with the statement. 78(78%) respondents agreed on the statement: I used hand lens to magnify objects and small specimens, while 22 (22%) disagreed with the statement. 60(60%) respondents agreed on the statement: I used hand lense to view invisible microorganism while 22 (22%) disagreed with the statement. This implies that the majority of the respondents among secondary school Teacher make the use of digital resources for effecting teaching of Biology in Ilorin West LGA senior secondary schools**.**

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary

The study shows the digital resources available for teaching biology in Ilorin West LGA senior secondary schools. It was revealed that large number of the respondents among secondary schools teachers agreed that majority of digital resources are available for teaching biology in Ilorin West LGA senior secondary schools.

The study also shows the extent of utilization of digital resources for teaching biology in Ilorin West LGA senior secondary schools. It was revealed that majority of the respondents among secondary school Teacher make the use of digital resources for effecting teaching of Biology in Ilorin West LGA senior secondary schools **.**This supported by the study of Wheeler, (2010). Who stated that Imperatively, the role that digital teaching resources play in the educational and learning environment cannot be over emphasized. The use of digital teaching resources in modern learning environment ranges from slide use of computers in practical aspects to an online learning experience which enhances and improves students' intellectual and learning behavior (Smith, 2003). With the introduction of computers, the precursor of our modern-day ICT, and the promising potentials of computer-based instruction and learning, many researchers and institutions were motivated to invest viable resources so as to ensure the possibility of computers enhancing learning culture. Many authorities believe that computers should be brought into the education system because of the expectation that students would benefit quantitatively from computers by providing them with the software and hardware for an effective learning process.

Ngonso N. (2018) also submitted that Digital teaching resources has received much attention from various institutions and academic scholars in the past few years. Digital teaching resources is a computer based educational system that enables learner to learn anywhere and at any time. Digital teaching resources is mostly delivered through the internet, although in the past it was delivered using a blend of computer-based methods like CD-Rom. The use of Digital teaching resources tools in respect to learning process is critical for the successful implementation of various learning environments Abdullah & Azzedine, 2011 noted that modern classroom, whether online or schools-based, use Digital teaching resources tools and learning management systems that capture student cognition and engages them in the learning process via technology, while increasing their need for self-directedness.

Lastly, the study shows the challenges facing biology teachers in the utilization of digital resources in Ilorin West LGA senior secondary schools. It was revealed that majority of the respondents among secondary school teachers agreed on the Challenges teacher face during the Utilization of Digital Resources in Ilorin West LGA Senior Secondary Schools.

Conclusion

The study concludes that majority of the respondents among secondary school's teachers agreed that majority of digital resources is available for teaching biology in Ilorin West LGA senior secondary schools.

The study also concludes that majority of the respondents among secondary school Teacher make the use of digital resources for effecting teaching of Biology in Ilorin West LGA senior secondary schools**.**

Lastly, the study concludes that majority of the respondents among secondary school teachers agreed on the Challenges teacher face during the Utilization of Digital Resources in Ilorin West LGA Senior Secondary Schools.

Limitations to the Study

All research projects have limitations and the present one is of no exception, therefore the limitations are stated below;

This study was only carried out in Ilorin west local government area and secondary school teachers were randomly selected, as such the result cannot be generalized to the entire secondary school teachers in the State and Nation at large.

The study consisted of just one hundred (100) participants, which seems to be far from the number of secondary school teachers in Ilorin west local government are and Kwara State.

Recommendations

Based on the findings in this study, the following was recommended:

Based on the findings in this study, the following was recommended:

Secondary school teachers should be encouraged and motivated on the use of digital Teaching Resources on to improve Secondary School Biology Students academic performance.

Government should strive and set aside a reasonable amount of education budget which will be directed to improve and construct facilities in schools to promote teachers use of digital Teaching Resources.

The heads of schools should teach the teachers and organize seminars on how to use Digital Teaching Resources for teaching secondary school students.

The parents should not sit down and wait for the government to effect on the availability of Digital Teaching Resources and facilities in secondary schools.

The parents should consider the problems of Digital Teaching Resources facilities as a challenge that needs to be redressed by them. So the study urges parents to effectively participate physically and financially where possible for the development of the use of Digital Resources for teaching

Suggestions for Further Study

Based on the findings in this study, the following areas are suggested for further study:

Teachers and students use of Digital Resources for effective teaching and learning in secondary schools

Perception of secondary school teachers on the use of Digital Resources for teaching in secondary schools.

Challenges facing the Usability and Availability ofDigital Teaching Resources for teaching

Effectiveness ofDigital Resources in the teaching and learning among secondary school teacher and students.

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Career Advancement and Financial Security: Tackling Sustainable Millennium Development Goal One Among Academic Staff in Nigeria

By

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Abstract

The fundamental purpose of employment and career pursuits is to earn income to satisfy essential life needs, including food, shelter, clothing, overall well-being, and the realisation of personal aspirations. However, there seems to persistent disequilibrium between academic staff career path and their financial security. The job of academic staff is meant to improve their lifestyle and financial security to promote Sustainable Development Goal One (SDG 1), which targets the need to overcome poverty everywhere. The presence of financial insecurity may pose a deterrent to the achievement of this goal among academic staff in Nigeria. This study therefore investigates career advancement and financial security among academic staff in Universities in Lagos state. A mixed-method research design, specifically the exploratory sequential type, was adopted for this study. The population of the study consists of ten Universities in Lagos State, Nigeria. The population of academic staff is 3197 from all the universities in Lagos State, Nigeria. The sample size for this study was 411. It was obtained using Taro Yemane's sample size calculator. A Multistage Approach using purposive sampling techniques was used for selecting academic staff in the universities. A questionnaire titled the "Career Advancement and Financial Security of Academic Staff (CAPNFSAS)" was employed as the study's instrument. Cronbach's Alpha statistical tool will be used to determine the internal consistency of the research instrument. Reliability coefficients of 0.75 pre-test and 0.75 post-test were obtained for the ASCAQ. The data obtained from the field study were analysed using descriptive and inferential statistics. Research questions were answered with the mean and standard deviation. Inferential statistical tools, Pearson Product Moment Correlation (PPMC) was used to test Hypotheses 1,2, and Linear Regression was used to test Hypothesis 3. All Hypotheses will be tested at the .05 level. The study discovered that promotion was significantly associated with financial security, also research was found to improve financial security, while recognition was found not to improve financial security and was significantly related among academic staff. However, it was recommended, among others, that there is a need to revisit capacity-building and career advancement training programs for timely promotion, grant-winning, and research writing to promote SDG 1 and reduce financial insecurity among academic staff in Nigeria.

Keywords: career advancement, financial security, Sustainable Development Goal One, poverty, promotion, research grant, and recognition.

Introduction

The fundamental purpose of employment and career pursuits is to earn income to satisfy essential life needs, including food, shelter, clothing, overall well-being, and the realisation of personal aspirations. Accordingly, every profession is expected to generate sufficient income to support these fundamental requirements, including academic staff within universities. Universities serve as vital institutions for research and the development of human capital, a mission that is heavily dependent on the retention of qualified academic personnel committed to scholarly excellence. Despite this, there seems to be a disequilibrium between the responsibility shouldered by the academic staff and the income they receive. Where academic staff experience insufficient income to meet their basic needs, save for unforeseen contingencies, and maintain resilience in the face of economic shocks, it can be termed as financial insecurity. A financially secure income caters to basic, emergency, and health needs, retirement plans, and guarantees future financial stability without reliance on loans or any fear of financial inadequacy. All these financial issues must be addressed to achieve Sustainable Development Goal One. However, the literature suggests that, financially, many academic staff nearing retirement lack the funds needed for a comfortable life (Prawitz et al., 2006, cited in Delafrooz & Paim, 2011).

The Sustainable Development Goal One (SDG 1) targets the need to overcome poverty everywhere. The presence of financial insecurity may pose a deterrent to the achievement of this goal among academic staff. Poverty is meant to be alleviated through employment. Being on a career path with good financial security may eliminate poverty, but this seems far from reality among academic staff. Financing for Sustainable Development Goal Report Five (2019) reported that, despite being employed in different careers, millions of workers still live in poverty due to low income. Based on the report, it seems that there is a huge gap between being employed and being financially secure through that employment. Salawu and Alfakoro (2023) affirmed that the lack of financial security among academic staff in Nigeria may have instigated innumerable adverse effects, ranging from protests, strikes, corruption, dismal performance, slow advancement, side work, and nonchalant attitude, among others, within the academic staff in Nigeria. Some of these protests and strikes are still ongoing. Lack of financial security from jobs might be a major contributor to more increase in negligence and lack of motivation. It may be true that academic staff in Nigeria are no longer satisfied with their jobs and income, as living standards and inflation continue to rise in the country. Nowadays, economic life is tougher; workers face higher food prices, energy costs, and health care expenses. Delafrooz & Paim (2011). They seem to have the status of being “employed,” yet their take-home pay makes them just a little better than people who are not fully employed.

This decline in financial security underlines the importance of career advancement, indicating how academic staff can progress financially through promotions, research work, and recognition. Career advancement refers to the progression of an individual's career via promotions, increased responsibilities, and improvements in job titles and salary. Career development entails navigating through different career stages and transitions. Building skills, experience, and certifications needed to thrive and advance in a career path is essential for career progression. Andresen et al. (2021) noted that promotions are largely attributable to differences in human capital. Employees must develop their capacity to achieve promotions. Academic staff can leverage promotions, leadership appointments, social mobility, and recognition associated with career advancement to enhance their financial well-being. Several factors have been identified as indicators of career advancement that can determine financial security, such as the promotion of academic staff from one level to a higher level in their careers.

It is instructive to note that promotion may come with the appointment of academic staff for leadership opportunities in an institution or in other parastatals of the country, increasing access to lead, supervise, and access to benefits connected to that leadership position. Promotional benefits range from an increase in salary increment, social status upliftment, bonuses, and professional development opportunities. Biemann and Braakmann (2013 asserted that careers develop pay off over time in terms of financial success, especially through promotions and salary increases. Also, Ojokoh and Akinola (2017) affirmed that the excellence of an academic staff member leads to promotion, added ranking, and financial value in return. Inversely, academic staff promotion has been observed to have financial implications resulting from the need for more research investment. Their promotion also involves high-index and international publications, which are not low-cost. The minimum quantum of publications required for a professorial promotion is six international publications and three international publications for associate professors (University of Lagos Authorship policy, 2022). However, it has been observed that most of these international publications and high-index journals have cost implications higher than those of local publications. A step higher in their career through promotion with a pay increase may be used to sub-charge some of these financial needs.

Likewise, the academic staff's onus is centered around teaching, research, and community development. Quality research work appears to attract grants, collaboration, and partnership from private companies, Non-Governmental Organizations (NGOs), and parastatals that may award contracts and seek research to be conducted for their products, services, innovations, or goals. NGOs, international organizations, and research agencies also seek ready research that has been conducted so they can invest or make decisions from the findings. Investing and skilling in R&D have globally been used not just for promotion at work (Ling, 2022) alone but also to solve problems and increase financial returns on research projects (Soltanisehat & Alizadeh, 2019). Ojokoh and Akinola (2017) also noted that value returned from research collaborations done with international colleagues yields financial returns as benefits for the home universities, aside from adding to the university ranking. Fershtman and Gandal's (2011) research showed that good research work can be monetized or put on patent. Consequently, a researcher known for quality research work may receive more readings, citations, and collaborations. Valued research data may require payment before granting access or permission to be used. Prominent academics who have reached such a rank in their research may benefit from the snowballing effect of the financial benefits that come with it.

Similarly, recognition is an important aspect of career advancement. Recognition means that staff are known in their field and beyond for their expertise and specialization. To foster such recognition, the National Universities Commission (NUC) has mandated that publication and citation of University academic staff must now be seen on Scopus, Google Scholar, Semantic Scholar, Research Gate, and ORCID, to mention a few, and also that their institutional email be regularly used. Based on this agreement, Universities now compel their staff to carry out these registrations and upload all their research work online to gain more ranking. Recognition seems to be increasing with local and international conference attendance, team publication, collaboration, and online presence. While academic recognition can open doors to high-paying careers, achieving financial success is not solely determined by scholarly achievements. Networking, entrepreneurial skills, among others, play crucial roles in financial success (Geri, 2019). Recognition may allow investors and partners to see researchers or academics as experts, prominent, and active in their field. Local and international participation may be needed to attract benefits from recognition.

Empirical review

Adedapo, Abiri, and Adedapo (2024) studied the relationship between staff promotion and welfare and the job productivity of non-academic staff in public universities in Southwest, Nigeria. Their results revealed a significant relationship between staff promotion, welfare, and non-academic staff job productivity. Abdulmumini (2021) investigated the impact of Promotion on Academic Staff Development in the State Higher Educational Institutions of Borno State. The finding reveals that since 2015 to date, the Borno State government has offered paper promotion with no monetary increment to the salary of academic staff in the state's higher education. The study also reveals that there is a significant relationship between promotion and academic staff development. Rahim and Daud (2012) conducted a study to identify the relationship between reward and employee work. The study adopted 133 questionnaires have were used for respondents consisting of permanent and contract workers. The results show that the reward system is an important aspect of motivating employees to encourage employees to achieve their goals. The study of Asaari, Desa & Subramaniam (2019) examined that reward and work motivation are very important for organisational workers, as this can be used to direct the staff towards achieving the goals of the organisation. The result concluded that there was a positive and significant relationship between rewards and motivation reward increase, the motivation of employees will also be increased, and they will long as the worker gets promoted to a higher level. Soltanisehat and Alizadeh (2019) researched Research and Development Investment and Productivity Growth in Firms with Different Levels of Technology. They found that Research and Development (R&D) with new technologies and innovation are contributors to economic growth. They observed that investing in research improves productivity, which in turn increases income. Results showed that R&D expenditures in high-tech and then in medium/high-tech industries have the most positive and significant effect on their economic growth. The visible hand of research performance assessment was studied by Hamann (2016) among universities in the United Kingdom. He discovered that research performance is measured by research quality. A quality research output attracts grants and funding for cooperating partners. Ojokoh & Akinola (2017) noted that value returned from research collaborations done with international colleagues yields financial returns as benefits for the home universities, aside from adding to the university ranking. Monetizing and patenting research findings are avenues for increasing returns from research (Fershtman & Gandal, 2011), provided the research is of a quality and problem-solving. Consequently, a researcher known for quality research work receives more readings, citations, and collaborations.

Also, research by Rosita, Fazri, Musnaini, and Aira (2022) examines the remuneration and recognition in influencing the work engagement of lecturers. The research design used survey research with quantitative research, and a structured questionnaire for data collection. Lecturers who received remuneration (PNS) at Jambi University, the research. sample consisted of 89 lecturers were sampled. The results showed that remuneration and recognition have a positive effect on work engagement. They reported that it is necessary to practice strong management in implementing remuneration so that it can be perceived as well as recognition, which is able to create prosperity and strong attachment in carrying out their duties as a lecturer. Asaari, Desa, and Subramaniam (2019) found that rewards from recognition increase financial rewards and visibility. Intrinsic rewards such as appreciation and recognition are important and have their own functions in stimulating employee attitudes and improving their performance.

In essence, academic staff career advancement emphasizes the importance of personal effort that can be geared toward financial freedom. Incidentally, educational managers, institutions, and even academic staff unions focus mostly on government assistance for financial upliftment out of poverty, which has yielded no results to date. It may be that career advancement could help in solving the financial situation among academic staff in Nigeria at present. It is against this background that the study examines career advancement (promotion, research, and recognition) and financial security among academic staff in public Universities in Lagos state, Nigeria.

Statement of the problem

Sustainable Development Goal One (SDG 1) targets the need to overcome poverty everywhere. The presence of financial insecurity may pose a deterrent to the achievement of this goal among academic staff in Nigeria. Salary and allowance controversy between the financier of public higher education (the government) and the academics seems to be unending. The government keeps trying its best on payment of academic staff incomes, but academics, on the other hand, feel the government has not done enough to meet their financial needs and standards to match up with professionals in other careers. Hence, there is a disequilibrium which had led to constant tensions, birthing unending issues in the university system. Academic staff retire at the age of 70, with 35 or more years of service to their institution, government, and their nation. On retirement, some professors in universities without accommodation spend extra days in the staff quarters so they can arrange shelter for themselves and their families; otherwise, they become displaced. The poor incomes received during the active service years could hardly achieve a good retirement plan since the majority of the incomes are spent on consumption. Microeconomic indices, especially inflation and unstable policies, have gradually eroded the disposable value of their income. To make ends meet, some academics come from far distances like Ikorodu, Mowe, and Ayobo areas, which have consequential effects on productivity, decline work enthusiasm, cause low work engagement, and health issues.

Poor lifestyle, inability to meet basic life needs, emergency needs like the situation of health issues leading to loss of life of some academic staff during the last (Academic Staff Union of Universities) ASUU strike in 2022 where their salaries were held back for eight months (Edema, Tolu-Kolawole & Oyekola, 2024) have resulted in more disengagement, government-academic Staff union court matters, and various protests. Even when there is no strike, an emergency need of academic staff could come up at any time, but their salaries mostly cannot cover it, leading to obtaining a loan or loss of life in the case of inability to secure loans and financial support.

The inability to find a solution to the issues of financial security of academic staff may even account for the brain drain known as "Japa" in the profession. Academic staff now seek greener pastures in other countries where they can close the gap between their work and their pay to have a financially secure life. There also seems to be low morale among would-be academics who now have the fear of remaining poor for the rest of their lives, and others who will not even be willing to take up the teaching, lecturing, or academic profession after schooling.

This study, therefore, will examine career advancement and financial insecurity among academic staff in public Universities in Lagos, Nigeria.

Theoretical Frameworks

The study is anchored on the Human Capital Theory and Income Trajectories theory.

Human Capital Theory (Becker, 1962)

Human Capital Theory was propounded by economist Gary Becker in 1962. Becker's pioneering work on human capital theory dates back to the 1960s and continues to influence discussions on education, skills advancement, labor economics, and workforce productivity. Human Capital Theory is an economic concept that views education, training, and skill advancement as investments in human capital that can lead to higher productivity, earnings, and economic growth. The theory posits that individuals can enhance their market value and earning potential by acquiring and developing valuable skills and knowledge, similar to how companies invest in physical capital (such as machinery and equipment) to increase productivity. The theory laid the foundation for understanding the economic value of human capital and the role of education and skill advancement in shaping individual success and economic outcomes. Academic staff can invest in their human capital by pursuing continuous professional development, attending workshops and conferences, engaging in peer collaboration, and acquiring new teaching strategies and methodologies. By investing in their professional growth, academic staff can enhance their teaching skills, adapt to changing educational trends, and increase their market value in the education sector. Academic staff who improve their human capital through ongoing professional development and skill-building activities can expect to see returns in the form of career advancement, higher job satisfaction, increased opportunities for leadership roles, and potentially higher salaries. Enhanced human capital can also lead to improved student outcomes, better classroom management, and increased recognition within the educational community.

Income Trajectories Theory (Janet Dearing, Kathleen McCartney, Matthew C. Taylor, 2001)

Income trajectory has been primarily studied within the field of economics and labor market research to understand how individuals' earnings evolve over their working lives. While there is not a specific individual credited with propounding the concept of Income Trajectories, it has been a key area of research in the fields of labor economics, human capital theory, and income inequality. Scholars Janet Dearing, Kathleen McCartney, and Matthew C. Taylor have investigated various aspects of Income Trajectories, including wage growth, income mobility, earnings differentials across occupations and industries, and the impact of education, skills, and work experience on income trajectories. The concept of Income trajectory refers to the pattern of changes in an individual's income over time, including the factors that influence income growth, stability, and fluctuations throughout one's career. In line with the concept of career advancement and financial security of academic staff, the Income trajectory theory is particularly relevant to academic staff's career advancement skills and financial security, as it can shed light on the potential earnings trajectories of academic staff over their professional lives. Understanding the income patterns and factors influencing academic staff earnings can help inform decisions related to professional development, salary negotiations, retirement planning, and overall financial well-being in the field of education.

Research Hypotheses

The following null hypotheses were formulated and will be tested at a .05 level of significance.

1. Promotion has no significant relationship with the financial security of academic staff.
2. Research engagement has no significant relationship with the financial security of academic staff.
3. Recognition does not significantly predict the financial security of academic staff.

Methodology

A mixed-method research design, specifically the exploratory sequential type, was adopted for this study. The population of the study consists of ten Universities in Lagos State, Nigeria. The population of academic staff is 3197 from all the universities in Lagos State, Nigeria. The sample size for this study was 411. It was obtained using Taro Yemane's sample size calculator. A Multistage Approach using purposive sampling techniques was used for selecting academic staff in the universities. A questionnaire titled the "Career Advancement and Financial Security of Academic Staff (CAPNFSAS)" was employed as the study's instrument. Cronbach's Alpha statistical tool will be used to determine the internal consistency of the research instrument. Reliability coefficients of 0.75 pre-test and 0.75 post-test were obtained for the ASCAQ. The data obtained from the field study were analysed using descriptive and inferential statistics. Research questions were answered with the mean and standard deviation. Inferential statistical tools, Pearson Product Moment Correlation (PPMC), were used to test Hypotheses 1,2, and Linear Regression was used to test Hypothesis 3. All Hypotheses will be tested at the .05 level.

Data Analysis

Test of Hypotheses

Research Hypothesis One

H_{01}: Promotion has no significant relationship with the financial security of academic staff.

Table 8

Relationship between Promotion and Financial Security of Academic Staff

Variables	Mean	S.D.	N	Df	R	p-value	Decision
Promotion	2.59	.449					
			411	409	.335**	.000	**Reject H_{01}**
Financial security	2.52	.53					

Source: Researcher's Computation, 2025. *Significant at the .05 level.

Analysis in Table 8 showed the result of Pearson Product Moment Correlation in determining the significant relationship between promotion and financial security. The information in the table showed r = .335**; df = 409 and a p-value of .000 < .05 level of significance. This implies that the null hypothesis was rejected. The correlation coefficient showed a low and positive significant relationship between promotion and financial security among academic staff in Universities in Lagos State, Nigeria.

Research Hypothesis Two

H_{02}: Research engagement has no significant relationship with the financial security of academic staff

Table 9

Relationship between Research Engagement and Financial Security of Academic Staff

Variables	Mean	S.D.	N	Df	R	p-value	Decision
Research Engagement	2.52	.53					
			411	409	.306**	.000	**Reject H_{02}**
Financial security	2.87	.55					

Source: Researcher's Computation, 2025. *Significant at the .05 level.

Analysis in Table 9 showed the result of Pearson Product-Moment Correlation in determining the significant relationship between research engagement and financial security. The information in the table showed r = .306**; df = 409 and a p-value of .000 < .05 level of significance. This implies that the null hypothesis was rejected. The correlation coefficient showed a low and positive significant relationship between research engagement and financial security among academic staff at Universities in Lagos State, Nigeria.

Research Hypothesis Three

H_{03}: There is no significant correlation between recognition and the financial security of academic staff

Table 10

Prediction of Recognition on Academic staff Financial Security

Model	Unstandardised Coefficients B	Std.Error	Standardised Coefficients Beta	T	Sig.	Decision
Constant	2.264	.078		28.854	.000	**Reject H_{03}**
Recognition	.179	.036	.239	4.987	.000	

Dependent Variable: Financial Security

Model Summary: R^2 = .057 (Goodness-of-fit Index)

ANOVA: F-value = 24.871 (p-value = .000)

Source: Researcher's Computation, 2025. *Significant at the .05 level.

Table 10 shows the model summary result reveals goodness of fit index R^2 = 0.057 (57%); indicating model fit is significant at F-value = 24.871 (p<0.05) significant level. Hence, the model is acceptable for further analysis. The result of the analysis revealed that recognition is significant at t = 4.987 (p<0.05). Hence, the hypothesis is rejected at 5% significance level since p = 0.000<0.05; therefore, recognition has a direct significant correlation with the financial security of academic staff in universities in Lagos state, Nigeria. Consequently, based on the standardized Beta coefficient, there is a significant positive relationship between recognition and financial security at r = .179

($p<0.000$). Hence, a unit increase in recognition will financial security among academic staff in Universities in Lagos State, Nigeria.

Discussion of Findings

The findings from hypothesis one showed a positive and significant relationship between promotion and financial security among academic staff. This outcome, as shown in research hypothesis one on Table 8, agrees with the outcome of the study conducted by Adedapo, Abiri and Adedapo's (2024) that promotion increases staff welfare and productivity. This implies that, the awareness of a financial gain at the end of appraisal boosts the motivation of workers to be hardworking since it will bring an additional financial gain. This is against the findings of Abdulmumini (2021), which showed that despite the effort of employees to get promoted in Borno state , it comes with no financial increase but just a mere paper notification, as a result workers are not interested in working hard for promotion. This implies that when promotion of academic staff without an increment in their take-home pay is as good as nothing hence, have not financial value. Rahim and Daud (2012) also support the findings of that study with results showing that the reward system is an important aspect of motivating employees to encourage employees to achieve their career goals. In the same vein, Asaari, Desa & Subramaniam (2019) agreed that reward and work motivation are very important for organisational workers. Hence, organisations must make attractive and effective reward policies and procedures to provide employee satisfaction and motivation. Sometimes employers are more focused on extrinsic rewards but intrinsic rewards. This result implies that the promotion of academic staff from one level to a higher level increases the financial income.

Research engagement is observed to have a significant relationship with financial security as indicated in the table 9 which showed the result from hypothesis two. This is in consistent with the research by Soltanisehat & Alizadeh's (2019) report that investing in skills towards developmental and problem-solving research increases financial returns from such research projects. This implies that with adequate research skills, academic staff could embark on developmental research and achieve financial benefits. It also supports the study of Ojokoh and Akinola (2017) that value returned from research collaborations with international colleagues yields financial returns as benefits for the home universities, aside from adding to the university ranking. This finding corroborates with Fershtman and Gandal's (2011) research that good research work can be monetized or put on patent for financial gains. Also, Hamann (2016) supported that a quality research output attracts grants and funding for cooperating partners.

The result from hypothesis three revealed that recognition has a direct, significant correlation with the financial security of academic staff. This implies that an increase in recognition will improve the financial security of academic staff. The finding is in line with the research by Rosita, Fazri, Musnaini, and Aira (2022), through recognition lectures can create prosperity and develop strong passion in carrying out their duties. Also**,** Asaari, Desa & Subramaniam (2019) found that rewards from recognition increase financial income and visibility. This implies that Intrinsic rewards, such as appreciation and recognition, are important and have their own functions in stimulating employee attitudes and improving their career performance.

Conclusion and Recommendations

Based on the findings, it could be concluded that improving financial security among academic staff is just about Union and government controversy. However, some personal steps can be taken by academic staff to tackle poverty to attain SDG 1. The following recommendations were therefore made:

1. One of the ways to promote SDG 1 and reduce financial insecurity among academic staff is to revisit capacity-building and career advancement training programs for academic staff. This training should empower academics on skills for timely promotion, grant winning, and research writing.
2. Emphasis should be placed on the importance of embarking on quality research and problem-solving findings that could attract grants, investors, and partnerships with private organizations. The result from such viable data can also be sold online before granting access.
3. NUC accreditation should not just be checked on if the university meet the standard on teaching and ranking. But also a check on the welfare and financial security of university lecturers.

4. The Government should, as a matter of urgency, increase its funding on academic research and take actions to improve institutional-industrial synergy to increase patronage of academic research from private stakeholders.
5. Pension fund administrators at the National Pension Commission (PenCom) can use the results from this research to plan new strategies to improve and advise on academic staff's retirement and investment planning.
6. Institutional managers and staff training centers should trained on various career advancement to plan, train, orient, and participate in the financial well-being of their staff.
7. There should be improve staff welfare packages, and timely staff promotions to enhance job performance.
8. Academics should know how to patent and keep results and provide it to those who need them after payment.

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EFFECTS OF BLENDED LEARNING MODE ON SENIOR SCHOOL STUDENTS' PERFORMANCE IN CELL BIOLOGY IN ILORIN, NIGERIA

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ABSTRACT

This study investigated the effects of blended learning mode on senior school students' performance in cell biology in Ilorin Nigeria. The design used was quasi experimental factorial design of 2x2 pretest, post-test, non-randomized, non-equivalent control group. Two co-educational senior secondary school in Ilorin, were purposefully selected based on year of establishment, availability of computer, biology teachers and number of arms of classes. Two research questions that translated to research hypotheses were formulated and tested intact science class of SS2 in each of the chosen schools were selected for the study. Students in the experimental group I were taught and assessed using blended learning mode, and the control group were taught using the conventional method. The researcher designed Cell Performance Test (CPT) which was validated by three experts with a reliability coefficient using Pearson Product Moment Correlation 0.84 used to obtain data for the study. The data collected were analyzed using t-test. Findings revealed that the blended learning mode had significant effect in the performance of students taught cell biology. The calculated t- value was significant at 0.05 alpha level, and those taught with conventional method but there was no significant difference in academic performance of male and female when taught with blended learning mode. Therefore, properly designed blended learning mode should be adopted by secondary school teachers in teaching Biology, as students benefit from the combination of face-to-face interaction and online resources.

Key words: Blended learning mode, performance, cell, gender

INTRODUCTION

Biology is a field of life science that deals with the study of life (Egunyomi & Osakwe, 2016). It is the scientific study of living things, including the structure, function, growth, evolution, distribution, and classification (Campbell, et al., 2021). Biology is recognized as a broad, and experimental field of study, and a crucial component of other disciplines of study that contribute significantly to the country's scientific and technological growth. These other fields of study include pharmacy, nursing, medicine, biotechnology, nanotechnology, and many more. The study of Biology at all educational levels can equip learners with beneficial concepts, principles and theories that will enable them live a peaceful life (Ahmad, et al., 2018).

Biology knowledge has greatly aided in the search for solutions to pressing issues such as increasing global food supply, controlling pests and diseases, producing growth hormones, protecting the environment, and studying the biology of microorganisms such as viruses that cause global pandemics such as the coronavirus (Ugwu, et al., 2020). Biology is crucial for mankind, however, research findings and reports from external examinations revealed senior school students' unimpressive performance in biology (Obi et al., 2020).

The effects of learners' poor performance in biology examinations is worrisome and poses a great question to what is happening at the classroom level in the senior secondary schools in Nigeria (Sheldon & Turner, 2019). Thus, the desire to know the factors responsible for poor performance in biology has been the focus of researchers for some time now.

In Nigeria, various topics in Biology are taught to learners at secondary school levels to lay a good foundation for future career. Among such topics that are taught include cell, ecology, genetics, micro-organisms, pollution, respiration, reproduction, and so on. Oyarole, (2023) reported that Biology concepts can sometimes be difficult particularly when describing ideas that are abstract and cannot be fully comprehended by learners for the first time. Research findings by Oyarole, (2015), Chief Examiners report of West Africa Examination Council (2018), have also shown that a number of concepts in Biology which include cell physiology contain topics that pose difficulty for Biology learners to understand. However cell physiology is considered as abstract in nature and difficult to understand which has resulted in poor performance among learners (Etobro & Fabinu (2017). In view of the above, cell cannot be taught using lecture method alone rather it requires more effective and pragmatic approaches that are activity based to enhance effective performance by learners because of its abstract nature.

Cell structure as a topic in the biology curriculum comes under the theme of organization of life. A cell is the smallest unit of life that can replicate independently, and cells are often called building blocks of life. The word cell (from Latin Cella, meaning "small room") is the basic structural, functional, and biological unit of all known living organisms (Michael, 2020). The knowledge of cell is a prerequisite for understanding Biology at any level and sub disciplines of biology as it lays the foundation on which other topics build on. Cell structure is an important topic that everybody needs to understand because of its invaluable roles in human life.

Blended learning approach (BLA) is an integrated system that harmonises the traditional method of face-to-face learning with e-learning through the Internet, to guide and assist the learner through each stage of learning as one of the modern approaches based on the use of educational technology in designing new educational situations (Elfeky & Elbyaly, 2019; Megahed & Hassan, 2022). Blended learning is a learner-centered learning method (Vasileva-Stojanovska, 2015) that combines traditional face-to-face classrooms (synchronous learning activities) with e-learning activities (asynchronous learning activities) (Attard & Holmes, 2020). Blended learning allows learners to visualize, listen, feel, and interact with the learning material. It moves them from theory into practice. They can gain deeper understanding for all the abstractions they get through. They can learn according to their pace, which creates the opportunity for more individualized education. .A blended learning model allows teachers and learners to interact, post polls, collaborate virtually through discussions, provide direct feedback through digital rubrics, align assignments to standards and curriculum, analyze grades, recognize achievement through rewards, and provide tools to create and complete assessments with technology tools but because applications and tools are constantly changing in the digital world, it is crucial that learners develop flexibility when using a technology tool; otherwise, learners will struggle to solve problems if that particular tool is no longer available (Tucker, et al., 2017).

Integrating technology tools into the teaching and learning process (usually known as e-learning) could help to close the gap created by conventional classroom approach. The concept of e-learning, as described by Sarigoz, (2019), involves utilizing digital electronic devices in the educational process, encompassing various tools such as audio and video devices, synchronous and asynchronous processes, and social media. This innovative practice, highlighted by Tucker et al., (2017), facilitates effective learning in the classroom and can take the form of fully online or hybrid learning experiences. E-learning involves a wide range of technology based learning through learning management systems, websites, learning portals, video conferencing, YouTube, mobile apps, and many other free available websites for blended learning., Learning Management Systems (LMS is one of the tools in technology that is commonly used to enhance knowledge and skills acquisition by learners, academic staff, and other professionals, through the Internet (Adams, et al., 2018; Chopra, et al., 2019).

Brush, (2019) defined Learning Management System (LMS) as a software application or web-based technology used to plan, implement and assess a specific learning process. It is an e-learning-based platform built on two major elements - a server that performs the base functionality and a user interface that is operated by an instructor, learners and administrators.

Brush, (2019) further stated that LMS enables an instructor to create and deliver content, monitor learners' participation and assess learners' performance. Brown (2020), investigated that LMS provides an avenue for the delivery and tracking of e-learning initiatives in one place. E-learning Basics (2021) asserts LMS as a platform for digital learning with the key features captured as follows; (1). Learning - It allows for the creation of a single source of online courses and training materials; (2). Management – It allows for the management of both courses and learners; and (3). System – It makes use of a computer system.

Scholars, while advising the need to adopt the LMS as a learning application, have identified some of its significance. Alecu, et al., (2011) revealed the ability of the LMS to: make learning easier and faster, promote interactive and collaborative learning experiences, encourage one to learn at his/her own pace, enhance flexible learning systems and give opportunities to learners to access the latest materials. In a study conducted by Binti, et al., (2016) it was reported that the LMS is capable of motivating learners towards learning thereby impacting positively on academic performance. Similarly, Mödritscher, et al., (2013) investigated a positive correlation between [1]learners' commitment to use of the LMS in learning and their academic performance. In this study, the LMS that was employed as the e-learning environment for the blended learning is Moodle. Moodle (Modular Object-oriented Dynamic Learning Environment) is an open-source learning management system that enables teachers to arrange their materials in a learner-friendly manner. Moodle is a free open source LMS built on a sound educational philosophy through collaboration from members.

Besides the instructional strategies a teacher employs during classroom instructions and the engagement of learners during learning, other factors that could influence learners' academic performance in Biology include students' gender. Gender can be a factor that could influence the application of technology such as learning management systems in the teaching and learning process. Nwona & Akogun (2015) observed that Science, Technology, and Mathematics were perceived as male-related subjects because male learners always show superiority in interest, participation, and achievement. Alghamdi and Bayaga (2016) had observed that learning management systems was not actively used for teaching which was as a result of the attitude of the members of staff, age and gender. Also, male and female biology students may differ in their response to the usage of e- learning and this may influence their achievement.

As pointed out in Ezenwafor and Obidile (2016), male and female who were taught biology using problem-based method did not differ significantly in their academic achievement and retention scores in the course. Therefore, male and female learners' performance in biology may differ when the course is taught with innovative approaches such as learning management systems. Thus, the importance of the current research stems from its topic, blended learning, which would be conducted to consider blended learning as an invented technique in teaching and developing the teaching methods used in teaching biology in the secondary schools by providing a new method of teaching where the information communication and technology is used without the need for a radical change in the conventional methods; the reason is that the blended learning method does not rely on the conventional methods but it works to improve them. It is against this background that this study determined the effect of harmonizing face-to-face with online instruction towards improving learners' academic performance in Biology.

Statement of problem

Biology is a fundamental science subject in the Nigerian school curriculum. Its significance cannot be stressed enough because of its potential to enhance the study and acquisition of relevant knowledge in scientific and technology necessary for sustainable healthy living and environmental management. However, with all the great benefits of Biology, research findings and reports from external examinations revealed senior school students' unimpressive performance in biology (Obi et al., 2020). This inconsistency and unimpressive performance can impede Nigeria's ambitions for scientific and technological advancement in the near future. This problem could be traceable to ineffective teaching strategies; difficulty in learning some biology topics and ill equipped laboratories, overloaded biology syllabus, learners' misconceptions and learners' study habits

In view of these, teaching of biology at the senior secondary school requires the right instructional strategies. Thus, there have been various teaching strategies that attempted to address issues with learners' unsatisfactory performance in Biology. Related literature on Blended learning such as that of Obe and Oladepo (2023) examined the influence of blended learning in enhancing academic achievement of biology in Adeyemi College of Education which is a higher institution and not secondary school. However, the study of Anachuna and Okigbo (2021) was conducted in basic science and not biology. Adams et al, (2017), investigated the impact of blended learning, which integrates face-to-face instruction and distance learning, on computer skills instruction for pre-med students at Arabian Gulf University in Bahrain and not in Nigeria

From the literature reviewed, it could be deduced that these previous studies differ from the present study in terms of: subject area, variable and location. Therefore, this study will determine the effects of blended learning mode on biology students' performance in Ilorin, Nigeria, where gender will be the moderating variable.

Purpose of the Study

The main purpose of the study is to determine the effects of blended learning mode on Senior School learners' performance in cell in Ilorin, Nigeria. Specifically, the study seeks to:

1. determine the difference in academic performance of learners taught cell using blended learning mode and those taught using conventional method.
2. investigate the difference in academic performance of male and female learners taught cell using blended learning mode.

Research Questions

The following research questions will guide this study:

1. What is the difference in performance of students taught cell using blended learning mode and those taught using conventional method?
2. What is the difference in performance of male and female students taught cell using blended learning mode?

Research Hypotheses

The following null hypotheses will be tested at 0.05 level of significance:

H_{01}: There is no significant difference in academic performance of learners taught cell using blended learning mode and those taught using conventional teaching method.

H_{02}: There is no significant difference in academic performance of male and female learners taught cell using blended learning mode.

METHODOLOGY

The research was a quasi-experimental research that adopts the post test control group design. The target population consisted of all senior secondary students offering biology in Ilorin, Kwara State, Nigeria. The researchers employed purposively sampling technique to select two coeducational secondary schools within

the geographical location. The school selected for the experimental had a functional computer laboratory and all other accessories like projector readily available. Hence the students have been exposed to receiving instruction through information communication technology. Research instruments used in this study were lesson plan on cell, learning management system instructional package on cell developed by the researcher, cell performance test (CPT) was constructed by the researcher. The CPT contained forty multiple choice questions. The research instruments were given to experts to validation. Thereafter, the reliability of the test instrument was obtained using Pearson's Product Moment Correlation (PPMC) with reliability coefficient value of 0.84 which was considered to be reliable and then used for the research. The experiment lasted for two weeks; the first week was used for administering the pretest so as to determine the equivalence of the two groups. Thereafter, the teaching exercise which lasted for three lessons was carried out simultaneously within both groups and at the end of the lessons; the post-test was administered to the respondent. In this study, there were two research questions with corresponding hypotheses. The hypotheses were tested with t-test at 0.05 level of significance. The analysis was done using statistical package for social science (SPSS) version 25.

RESULTS

Research Question 1: What is the difference in performance of students taught cell using blended learning mode and those taught using conventional method?

The mean and standard deviation of Table 1 shows that the performance of senior school students taught cell using blended learning (33.09) and convectional method (20.52) were both improved after the treatment with blended learning having higher mean gain score 12.57. To further ascertain if the difference was significant, the corresponding hypothesis was tested and reported in Table 1.

Table 1:

Pretest Mean Performance Score of Students in Experimental and Control Group

Table 1:

Pretest Mean Performance Score of Students in Experimental and Control Group

Variable	N	Pre-test Mean score	SD	Post test Mean score	SD	Mean	Gain diff
Experimental	85	17.60	4.05	33.09	3.97	15.49	10.19
Control	88	15.22	3.83	20.52	3.15	5.30	

Hypothesis 1: There is no significant difference in performance of students taught cell using blended learning mode and those taught using conventional teaching method.

Table 2 shows the t-test analysis result of the difference in the experimental and control. From the table t=4.93 at $p<0.05$, since the p-value 0.01is less than 0.05. The result indicated that there was a significant difference between those students taught with blended learning mode and those taught with conventional method of teaching.

Table 2:
The t-test Analysis of the Difference in the Performance of those taught with Blended Learning and Conventional Method when taught Cell

Treatment	N	Mean	SD	*df*	*t*	Sig	Remark
Experimental	85	33.09	3.97	4.93	0.01		
Control	88	20.52	3.15				

P<0.05

Research Question 2: What is the difference in performance of male and female students taught cell using blended learning mode?

The result from Table 3 revealed the mean score for the male respondent with 24.44 and female respondents with 22.20 in blended learning mode. This implies that male counterpart performed better than female counterparts with 0.64 differences.

Table 3: The Mean Score of Blended Learning mode based on Gender

Blended learning	N	Pre-test Mean	SD	Post test Mean	SD	Mean	Gain diff
Male	34	18.56	3.86	24.44	2.30	5.88	0.64
Female	51	16.96	4.08	22.20	4.30	5.24	

Hypothesis 2: There was no statistical significant difference in the performance of senior school students' taught cell using blended learning mode based on gender

Table 4 shows t-test analysis result (t 83=1.81; P>0.05) of senior school students exposed to blended learning mode when taught cell based on gender. The result indicates that there was no significant difference between the male and female respondent as the p-value 0.08 is greater than 0.05 significant levels. Therefore, the null hypothesis is not rejected.

Table 4: *The t-test Analysis of Senior School Students taught Cell using Blended Learning mode based on Gender.*

Blended learning	**N**	**Mean**	**SD**	***df***	***t***
Male	34	2.30	83	1.81	0.08
Female	51	4.30			

DISCUSSION

This study was conducted to investigate the effects of blended learning on senior school students performance on Cell Biology based on gender. Based on hypothesis one, the findings of this study showed that there was a significant difference in the performance of students taught cell using blended learning and those taught using conventional method of teaching. The students' performance was enhanced significantly better when taught using blended learning mode than their counterparts taught using conventional method. The findings shown in this outcome supports the findings of Adaihe et al., (2020), who found a statistically significant difference in the academic performance of students taught cell division in a blended learning environment compared to students taught in a regular classroom. The results are consistent with Njoku, (2024) assertion that blended learning raises students' academic performance. Moving forward, table 4 and table 5 data demonstrated that there is no statistically significant difference between male and female biology students who are taught through blended learning. This result is consistent with the findings of Umeana (2020), who found no discernible difference in the academic performance of male and female students taught in a mixed learning setting. In contrast, previous research (Panetta, 2017) found that when blended learning was used in the classroom, male students fared better than female students. Panetta,(2017) explained this achievement gap by pointing out that male pupils are more digitally inclined than female students. The results of recent research show that blended learning is gender friendly and can be used to teach all students, regardless of gender, suggesting that female students have clearly closed the technological knowledge gap.

Conclusion and Recommendations

Studies investigating the effect of blended learning on students' academic performance in Cell Biology have reported varied outcomes. A properly designed blended learning mode lead to improved learning outcomes, as students benefit from the combination of face-to-face interaction and online resources. However, the effectiveness of blended learning can depend on factors such as the quality of online content, teacher-student interaction, and individual student characteristics. Overall, the blended learning mode has the potential to positively impact students' academic performance in Biology in senior secondary schools. When implemented effectively, it can enhance engagement, understanding, and active learning. However, addressing challenges related to technology access, teacher training, and pedagogical balance is crucial to realizing the full benefits of blended learning.

Based on the findings, the following are recommended; (1) biology teachers in secondary schools should be trained on the effective use of blended learning as the method to improves the understanding of students in Biology classes, hence improving their academic performance; (2). schools should give every student equal opportunity in accessing the internet and other online study tools as a means of carrying everybody along.

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DEVELOPMENT AND EFFECTIVENESS OF A GAMIFIED LEARNING APPLICATION FOR SENIOR SCHOOL STUDENTS' PERFORMANCE IN BIOLOGY IN ILORIN, NIGERIA

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ABSTRACT

This study examined the development and effectiveness of a gamified learning application designed to enhance senior secondary school students' performance in Biology in Ilorin, Nigeria. The problem addressed centers on the persistent low achievement levels in Biology, attributed largely to conventional, non-interactive teaching methods that fail to sustain students' interest and engagement. The objective was to develop a gamified educational tool and assess its impact on students' academic performance and motivation. A quasi-experimental research design was adopted, involving pre-test and post-test control group measures. The sample consisted of senior school students randomly selected from two secondary schools in Ilorin, with one group exposed to the gamified application and the other taught using traditional methods. Data were collected through achievement tests and questionnaires and analyzed using descriptive and inferential statistics. The findings revealed that students who utilized the gamified learning application demonstrated significantly higher performance and engagement compared to their counterparts in the control group. Based on these results, it is recommended that educational stakeholders integrate gamified applications into the Biology curriculum to promote active learning and improved outcomes. The study concludes that gamification offers a promising approach to transforming Biology education, fostering better academic performance and sustaining student interest.

Keywords: Gamified Learning, Biology Education, Educational Technology in Nigeria, Academic Performance, Senior Secondary School Students

INTRODUCTION

Biology is a foundational science subject that plays a crucial role in students' understanding of life processes and contributes significantly to addressing global challenges in health, agriculture, and environmental sustainability. In Nigeria's senior secondary school curriculum, biology is not only compulsory but also pivotal for students aspiring to pursue science-related careers. Despite its importance, students' performance in biology has consistently been poor, largely due to the abstract nature of many biological concepts and the dominance of traditional teaching methods that prioritize rote memorization over conceptual understanding (Olarewaju, 2020). The disengagement of students with conventional, lecture-based instruction calls for innovative approaches that promote active learning. One such approach is gamification—the application of game-based elements such as points, levels, badges, challenges, and leader boards to non-game contexts like education. Gamified learning has gained attention for its potential to transform passive classrooms into dynamic and engaging learning environments. According to Miller and Rose (2015), gamified activities provide learners with a sense of agency, purpose, and excitement, thereby fostering deeper cognitive involvement. Moreover, gamification aligns with the constructivist view of learning, which emphasizes interaction, exploration, and real-time feedback.

Despite the recognized importance of biology in solving real-life problems in health, agriculture, and environmental management, students in Nigerian senior secondary schools continue to perform poorly in the subject (Olarewaju, 2020). This underachievement is largely due to the use of traditional, lecture-based teaching methods that promote rote memorization rather than active engagement and deep understanding (Fasuyi, Oladipo & Udeani, 2022). In resource-constrained areas like Kwara State, the situation is exacerbated by limited access to instructional materials and innovative teaching strategies (Adedoyin, 2019). While classroom-based gamification has been shown to improve engagement and learning outcomes (Adesoji & Olusola, 2019; Yildirim & Şen, 2021), most existing interventions are either non-digital or not tailored to the local context. There is a significant lack of research on the development and effectiveness of digital gamified learning tools designed for Nigerian students. This study aims to fill this gap by developing and evaluating a gamified application for teaching biology.

While much of the existing literature focuses on digital gamification in developed countries, its implementation in resource-constrained contexts like Nigeria remains underexplored. Classroom-based gamified strategies such as scavenger hunts, role-playing, quiz battles, and flashcard games have shown promise in enhancing engagement and improving knowledge retention among Nigerian students (Adesoji & Olusola, 2019; Ogunleye, 2021). Developing a gamified learning application tailored to the Nigerian educational environment offers a strategic way to harness technology for improved learning outcomes. Unlike conventional e-learning platforms, gamified applications use interactive design to make abstract biological concepts more tangible and relatable. Studies have shown that students who learn biology through gamified applications demonstrate better understanding and long-term retention of content than those taught through traditional means (Huang & Soman, 2013; Oladipo & Adebayo, 2020). Additionally, these platforms can integrate localized content and offline capabilities, making them suitable for schools with limited internet connectivity.

The issue of gender has also emerged as a significant factor influencing the effectiveness of gamified learning in biology. Almasri (2022) found that gender roles and societal expectations shaped students' performance in gamified settings. Female students excelled in collaborative tasks, while male students performed better in competitive environments. Feng et al. (2023) examined how cultural perceptions influenced gendered classroom interactions and observed that female students often exhibited discomfort when engaging with reproductive biology content in gamified discussions, whereas male students appeared more confident. Udeani and Akhigbe (2020) found that gamified environments improved the performance of both male and female students, although females displayed slightly higher academic gains in socially interactive environments. Almusharraf et al. (2023) similarly observed that female students responded more positively to team-based competitions, whereas male students preferred tasks emphasizing individual achievements. In contrast, Nguyen et al. (2022) reported higher engagement levels among male students, particularly in competitive gamified tasks involving rapid problem-solving. This pattern was also observed by Craven (2015), who found that males were more engaged in high-action, competitive virtual simulations. Additionally, Zahedi et al. (2021) demonstrated that narrative-driven gamification featuring storytelling and character development was more effective for female students, while Yang et al. (2014) observed that males excelled in spatially demanding simulations. Nonetheless, some studies suggest that gender differences in performance and engagement may not be statistically significant. Thaddeus (2021) and Tsai (2017) both concluded that when gamification is well-designed and contextually relevant, it can effectively neutralize gender disparities, resulting in equivalent performance improvements among male and female students.

In summary, leveraging gamified learning applications offers a promising solution to the persistent challenges in biology education. This study seeks to develop and evaluate a contextually relevant gamified tool aimed at enhancing students’ engagement and academic performance in biology among senior secondary school learners in Ilorin, Nigeria.

Purpose of the Study

The following stated purpose guided this study:

1. Develop a gamified application for learning biology.
2. Examine gender differences in post-test performance among students taught using the gamified application.

Research Questions

To achieve the purpose the following research question were investigated for answer as follow:

1. What are the processes involved in the design and development of a gamified learning application for biology?
2. What is the difference in the post-test performance of male and female secondary school students taught using a Gamified application for learning in biology;

Research Hypotheses

The following hypotheses were raised and will be tested in the study:

Ho_1: There is no significant difference in the post-test performance of students in the experimental group and those in the control group in biology.

Ho_2: There is no significant difference in the post-test performance of male and female students taught using the gamified application in biology.

METHODOLOGY

The study employed a design-based research of quasi-experimental pre-post test and control group design with a factorial structure to evaluate the impact of gamified learning on students' academic performance in biology.

Two intact classes of SSS 2 students of 40 students each from School A (control group) and School B (Experimental group) in Ilorin, Kwara State, were purposively selected as experimental and control groups, minimizing bias through their distribution across different schools. The experimental group students used a Gamified Learning App, while the control group students also received traditional instruction. Data were gathered using a pre-test and post-test, and a detailed lesson plan aligned with curriculum topics on musculoskeletal system. Instrument validity was ensured through expert reviews in the field of educational technology and Science Education, while reliability was confirmed via a pilot study using Cronbach's alpha. Ethical clearance was secured, and informed consent was obtained. Pre-and post-tests measured academic performance changes, while attitudinal responses offered qualitative insights. Data collection spanned six weeks, with procedures structured to ensure consistency, confidentiality, and alignment with ethical research practices. Data collected will be analyzed using descriptive and inferential statistics with SPSS version 23.0. Frequency, percentage, mean, and standard deviation will address demographic information and research questions, while t-tests at a 0.05 significance level will test research hypotheses to determine differences in student performance and responses based on study variables.

RESULTS

Research Questions 1: What are the processes involved in the design and development of a gamified learning application for biology?

The design and development of a gamified learning application for biology involve several key processes to ensure an engaging and effective learning experience. The first stage is content development, where the researcher identifies the learning objectives and selects an appropriate topic. In this case, the focus is on the **Musculoskeletal System (Axial System)** for SS2 students. The content is structured into four modules: **Musculoskeletal System (Week 1), Vertebrae II (Week 2), Pentadactyl Plan (Fore and Hind Limbs) (Week 3), and Joints, Muscles, and Ligaments (Week 4).** Each module is transformed into a detailed lesson plan that aligns with the curriculum and is validated by subject matter experts to ensure accuracy and instructional effectiveness.

Next is the gamification and design phase, where the application is structured into an engaging, interactive storyline. The storyline follows a character, **Sharon, who is stranded on Skeleton Island (Archipelago) and needs help restoring her skeletal system to regain mobility.** Players begin by entering their names and selecting an avatar, either male or female, to personalize their gaming experience. Each module features a lesson, followed by a five-question quiz that tests students' understanding of the topic. Completing quizzes correctly allows players to select the right bones to help Sharon, reinforcing their learning in an interactive way.

The development phase involves using appropriate technology to build the application. **Unity Game Engine** was employed for the interactive environment, while **C# programming language** handled the scripting for game mechanics. High-quality **graphics, avatars, and UI elements** were designed using **Adobe Illustrator and Photoshop**, ensuring an engaging and visually appealing experience. The application also integrates **Firebase** to store user progress and quiz scores, while **Blender** was used to create 3D skeletal models to enhance visualization.

User experience (UX) and interface design were prioritized to make the app accessible and engaging. **Typography, balance, and graphical elements** were carefully selected to ensure clarity and aesthetic appeal. The interface was designed to be intuitive, allowing students to navigate lessons and quizzes easily while immersing them in the learning process. Immediate feedback mechanisms were integrated into the quizzes to help learners assess their progress and reinforce knowledge retention.

The testing and refinement phase followed, where the application was evaluated through usability testing with a sample group of students. Their feedback was gathered to assess engagement, usability, and educational effectiveness. Additionally, subject matter experts reviewed the app to verify content accuracy and instructional value. Based on this feedback, improvements were made to game mechanics, visual elements, and quiz difficulty to enhance the overall learning experience. The landing page of the application is presented in figure 4 as observed the visual and content element were communicative and intuitive.

Figure 1: The Landing page of the gamified learning application

There are two buttons on the page: Objectives and Start. Clicking the Start button takes the user to the lesson dashboard, where they can select the module (week lessons) that corresponds to the lesson plan in the app. The modules as they appear in the application are depicted in Figure 2.

Figure 2: Lesson Dashboard

Research Question 2: *What is the difference in the post-test performance of male and female secondary school students taught using a Gamified application for learning in biology*

Table 1:

Comparison of Post-Test Performance Between Male and Female Students in the Experimental Group

Gender	N	Mean (X)	Standard Deviation (SD)
Male	23	78.15	9.45
Female	17	74.90	10.05

Table 2 compares the post-test performance of male and female students in the experimental group. The mean post-test score for male students was 78.15 with a standard deviation of 9.45, while female students had a mean score of 74.90 with a standard deviation of 10.05. This indicates that both male and female students benefited from the gamified application, but male students achieved slightly higher scores than their female counterparts.

Ho$_1$: There is no significant difference in the post-test performance of students in the experimental group and those in the control group in biology.

Table 3:

t-test Analysis of significant difference in the post-test performance of students in the experimental group and those in the control group in biology

Group	No	X	SD	Df	T	Sig (2tailed)	Decision
Experimental	40	76.75	9.79				
				78	9.13	0.000	Rejected
Control	40	59.65	6.67				

Table 3 compares the post-test performance of students in the experimental and control groups. The experimental group, which used the gamified application, had a mean score of 76.75 with a standard deviation of 9.79, while the control group had a mean score of 59.65 with a standard deviation of 6.67. The calculated t-value was 9.13, and the significance level was 0.000, which is less than 0.05. This led to the rejection of the null hypothesis, indicating that students who used the gamified application performed significantly better than those who were taught using traditional methods.

Ho$_2$: There is no significant difference in the post-test performance of male and female students taught using the gamified application in biology.

Table 4
t-test analysis of significant difference in the post-test performance of male and female students taught using the gamified application in biology

Gender	No	X	SD	Df	T	Sig (2tailed)	Decision
Male	23	78.15	9.45				
				38	1.04	0.302	Accepted
Female	17	74.90	10.05				

Table 4 examines the difference in post-test performance between male and female students taught using the gamified application. The mean score for male students was 78.15 with a standard deviation of 9.45, while female students had a mean score of 74.90 with a standard deviation of 10.05. The t-value was 1.04, and the significance level was 0.302, which is greater than 0.05. As a result, the null hypothesis was accepted, meaning there was no significant difference in post-test performance between male and female students. This suggests that the gamified learning approach was equally effective for both genders.

Discussion of Findings

The findings of this study provide critical insight into the impact of gamified learning on students' academic performance in biology, with a specific focus on gender differences in learning outcomes. The study investigated the development and implementation of a gamified learning application designed to teach the Musculoskeletal System to Senior Secondary School (SSS 2) students in Ilorin, Nigeria. It further compared the post-test performance of students exposed to gamified instruction with those taught using traditional methods.

The findings from the analysis revealed a systematic process in the design and development of the gamified learning application. Consistent with the instructional design models suggested by Huang and Soman (2013), the process began with **content development**, where key learning objectives were aligned with the Nigerian senior secondary school biology curriculum, particularly focusing on the Musculoskeletal System. The modularization of content into weekly lessons ensured that the information was not only structured but also scaffolded to promote progressive learning. Validation by subject matter experts further affirmed the instructional integrity of the content, an essential step recommended by Adedoyin (2019) for maintaining curricular relevance in educational technologies.

The **gamification and design phase** emphasized personalized learning, allowing students to select avatars and engage with an interactive storyline. Such personalization and storytelling strategies have been shown by Zahedi et al. (2021) to increase student engagement and intrinsic motivation. The development stage demonstrated an integration of advanced technological tools such as Unity Game Engine and C# programming language for interactivity, while Blender and Adobe Illustrator supported high-quality visualizations. This approach aligns with findings by Oladipo and Adebayo (2020), who emphasized that the aesthetic and technical quality of gamified platforms significantly impact students’ cognitive immersion.

Moreover, the application incorporated real-time feedback through quizzes, an essential component for reinforcing learning and promoting immediate corrective actions as advocated by Miller and Rose (2015). User testing and iterative refinement based on feedback from both learners and educators ensured that the final product was both user-friendly and pedagogically sound. Overall, the processes involved mirrored best practices in educational game design, highlighting the necessity of interdisciplinary collaboration between content experts, designers, and software developers in producing effective learning technologies.

The analysis of post-test scores between male and female students indicated that both genders benefited from the gamified application, although male students achieved slightly higher mean scores (M = 78.15, SD = 9.45) than female students (M = 74.90, SD = 10.05). This outcome resonates with previous findings by Nguyen et al. (2022) and Craven (2015), who reported that male students often exhibit higher engagement and performance levels in competitive, gamified learning environments.

However, the relatively small difference in mean scores suggests that the gamified application provided an inclusive learning platform capable of minimizing gender disparities, consistent with the conclusions of Tsai (2017) and Thaddeus (2021). These scholars argued that when gamification is designed to cater to diverse learning preferences—incorporating both collaborative and competitive elements—it can neutralize traditional gender performance gaps. The presence of both individual challenges and narrative-driven tasks in the developed application likely contributed to creating a balanced environment, accommodating the preferences noted by Almusharraf et al. (2023), where female students excel in team-based activities and male students thrive in individualistic, competitive settings. The findings thus underscore the potential of well-designed gamified applications to promote equitable learning outcomes across gender lines, especially in complex subjects such as biology.

The t-test analysis revealed a statistically significant difference in the post-test performance of students exposed to the gamified learning application (M = 76.75, SD = 9.79) compared to those taught with traditional methods (M = 59.65, SD = 6.67), with a t-value of 9.13 and a p-value of 0.000. As the p-value was less than the 0.05 significance level, the null hypothesis was rejected.

This result aligns with findings from Adesoji and Olusola (2019) and Yildirim and Şen (2021), who demonstrated that gamified learning environments significantly enhance academic performance by promoting active engagement, fostering intrinsic motivation, and enabling better retention of complex concepts. The significant improvement in the experimental group further validates Miller and Rose's (2015) assertion that gamification taps into students' intrinsic motivations by transforming passive content into interactive experiences that encourage deeper cognitive processing.

The traditional method's lower mean performance confirms previous observations by Fasuyi, Oladipo, and Udeani (2022) that lecture-based instruction often leads to surface-level learning and low academic achievement, especially in abstract scientific subjects like biology. This study, therefore, reinforces the need for innovative, technology-driven interventions in Nigerian secondary schools to bridge the persistent learning gap in science education.

Although the results showed that male students had a marginally higher mean score than female students, the difference was not statistically significant. This finding corroborates the conclusions drawn by Udeani and Akhigbe (2020) and Zahedi et al. (2021), who observed that gender-based differences in gamified learning environments tend to be minimal when the instructional design is inclusive and contextually adapted.

The balanced design of the application offering both collaborative and competitive elements, alongside an engaging narrative likely contributed to this outcome. Feng et al. (2023) and Almasri (2022) previously noted that culturally sensitive and pedagogically inclusive gamified tools can mitigate gender-based discomfort and ensure that both male and female students have equitable opportunities to succeed. Moreover, the use of avatars and personalized storytelling might have enhanced female students' sense of identification with the content, a factor emphasized by Yang et al. (2014) as critical to improving female engagement in digital learning environments.

Thus, the findings suggest that with thoughtful design, gamified learning applications can serve as gender-neutral pedagogical tools capable of promoting equitable academic outcomes among secondary school students in Nigeria.

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IMPACT OF CULTURALLY RESPONSIVE TEACHING AND AI-ENABLED INQUIRY-BASED LEARNING ON NATIONAL DIPLOMA STUDENTS' INTEREST IN DESKTOP PUBLISHING

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ABSTRACT

This study investigated the impact of Culturally Responsive Teaching (CRT) and AI-Enabled Inquiry-Based Learning (IBL) on the achievement, interest, and attitude of National Diploma students in Desktop Publishing. A quasi-experimental design was employed with three student groups: one exposed to CRT, another to AI-enabled IBL, and a control group taught with conventional methods. Pre-test and post-test data were collected using achievement tests and questionnaires. Findings revealed that the CRT group recorded the highest mean gain scores in both achievement and interest, demonstrating that integrating cultural relevance into the curriculum is highly effective for enhancing both academic performance and student motivation. The AI-enabled IBL group showed the most modest gains, suggesting that the technological and inquiry-based approach, while engaging, was less directly impactful on core learning outcomes in this context. Interestingly, the conventional teaching group showed the greatest improvement in attitude, though all groups finished with similar positive post-test scores. The study concludes that Culturally Responsive Teaching is a superior pedagogical strategy for Desktop Publishing education, effectively bridging the

gap between technical skill acquisition and students' sociocultural contexts. It is recommended that educators prioritize cultural relevance as a foundational element, potentially leveraging AI tools within this framework to further personalize and enhance learning.
Key words: Culturally Responsive Teaching, AI-Enabled Learning, Desktop Publishing, Student Achievement

INTRODUCTION

The imperative to effectively educate a diverse student population has catalyzed significant evolution in pedagogical research globally. In Nigeria, as elsewhere, effective teaching is fundamental to the acquisition of knowledge, skills, and values, with learning itself being a dynamic process integral to intellectual and social development (Kalantzis & Cope, 2020). Teachers act as crucial intermediaries between traditional knowledge systems and modern curricula (Somé et al., 2020), and their ability to adopt contextualized strategies is key to improving student retention and performance (Nwoke, 2024). As Darling-Hammond et al. (2020) emphasize, effective teaching is rooted in understanding student development and adapting practices to meet diverse needs to foster equitable outcomes.

Historically, Nigerian education, influenced by its colonial legacy, has relied heavily on standardized, teacher-centered instructional methods characterized by lectures, rote memorization, and passive student engagement (Afolabi, 2020; Sanubi & Akpotu, 2015). This approach persists due to factors such as inadequate infrastructure, extensive syllabi, and time constraints, particularly in Southwestern Nigeria's polytechnics (Ojo & Adu, 2017). A significant critique of this model is that it prioritizes content delivery over skill development, creating a disconnect between classroom instruction and real-world application and often reinforcing educational inequalities (Ezumah, 2020; Ogundele & Adebayo, 2023). This misalignment is especially acute in technical and vocational education (TVE), where practical competencies are paramount, and is increasingly unsuitable for preparing students with the problem-solving and adaptive skills required in the 21st century (Obanya, 2010; Okebukola, 2012). The shortcomings of this conventional approach, compounded by systemic issues like limited technological access, necessitate the adoption of more contemporary and innovative pedagogical strategies.

Contemporary pedagogy integrates novel instructional strategies and technological advancements to meet diverse learner needs and enhance academic performance (Holmes et al., 2022). Well-designed approaches like inquiry-based learning are renowned for fostering critical thinking (Kalantzis & Cope, 2020). In the Nigerian context, flexible teaching practices are essential for bridging access and comprehension gaps to ensure equitable outcomes (Nwoke, 2024). The integration of technology, through models like blended learning and flipped classrooms, has revolutionized instructional delivery by offering personalized and interactive learning experiences (Darling-Hammond et al., 2020). However, its effectiveness in Nigeria is hampered by challenges such as unstable electricity, inadequate funding, and insufficient teacher training (Kihwele, 2020). When implemented effectively, technology-enhanced strategies like project-based learning (PBL) have been shown to increase student satisfaction and problem-solving capabilities in technical courses (Lee & Lim, 2019). This study focuses on two specific innovative strategies: Culturally Responsive Teaching (CRT) and AI-Enabled Inquiry-Based Learning (AI-IBL), which together aim to make learning more inclusive, relevant, and engaging.

Culturally Responsive Teaching (CRT) utilizes students' cultural knowledge, prior experiences, and performance styles to make learning more effective and relevant (Gay, 2018). It fosters a sense of belonging, equity, and critical consciousness among diverse learners (Ladson-Billings, 2014). In vocational education, incorporating culturally relevant resources and local design elements has been shown to deepen student engagement and creativity (Makgato & Mothiba, 2015; Tella, 2017). For Nigerian students, CRT is critical for developing a curriculum that bridges global technological skills with local sociocultural contexts, making subjects like Desktop Publishing (DTP) more accessible and applicable (Agwuegbo, 2018; Oluwaseun et al., 2020).

Concurrently, Artificial Intelligence (AI) is increasingly pivotal in personalizing learning and enhancing educational outcomes (Tapalova & Zhiyenbayeva, 2022). In DTP, AI-powered tools can streamline content creation and editing, freeing up time for creative exploration (Sauerburger, 2024; Szandi, 2024). When integrated with Inquiry-Based Learning (IBL)—a student-centered pedagogy that emphasizes active investigation and problem-solving (Gholam, 2019)—AI can provide powerful, personalized educational experiences (Heffernan & Heffernan, 2017). This combination, known as AI-Enabled Inquiry-Based Learning (AI-IBL), holds significant potential for Nigerian higher education by offering tailored guidance and support throughout the learning process (Adewale & Oluwaseun, 2019). The integration of CRT and AI-IBL is particularly promising for a skill-based field like Desktop Publishing, which requires a blend of technical proficiency, creativity, and problem-solving ability (Hoadley, 2020). Learning outcomes, often measured through achievement scores (Ziliwu, 2022), and student interest, a key source of intrinsic motivation (Sarumaha, 2022; Harefa, 2021), are critical indicators of success. In technical disciplines, a positive attitude and resilience are essential for overcoming challenges, and achievement improves when instruction scaffolds technical knowledge with practical application (Darling-Hammond et al., 2020; Oyeniran & Kouassi, 2021). Research suggests that interactive, culturally relevant learning environments can enhance both software proficiency and design skills (Conradie, 2019), indicating that the combined approach of CRT and AI-IBL could significantly improve educational effectiveness in DTP (Alabi & Olamide, 2022).

Desktop Publishing is a core component of the National Diploma (ND) in Office Technology and Management (OTM) in Nigerian polytechnics, designed to equip students with the skills to create professional-quality publications using industry-standard software (NBTE, 2004). In a competitive job market, proficiency in DTP is highly valued across publishing, advertising, and corporate sectors (Adesina, 2021; Okebukola, 2012).

This background highlights the critical need to move beyond conventional teaching methods in Nigerian TVE. This study is therefore essential as it provides a framework that addresses the diverse cultural and technical learning needs of National Diploma students. It examines the combined impact of Culturally Responsive Teaching and AI-Enabled Inquiry-Based Learning on the interest and learning outcomes of Desktop Publishing students in Southwestern Nigerian polytechnics.

Statement of Problem

Many students in Southwestern Nigeria struggle to attain the best learning results, even though desktop publishing (DTP) is becoming increasingly recognized as a crucial skill in vocational education. Numerous factors contribute to this difficulty, such as uneven curriculum design, insufficient teacher support, large class size and restricted access to contemporary technologies (Hohlfeld, Ritzhaupt, Dawson, Wilson 2017). Students' capacity to successfully retain and apply DTP concepts is also greatly influenced by cognitive elements such past knowledge and metacognitive abilities (Sweller, 2011). This study aims to fill the knowledge gap by replacing the conventional teaching approach with contemporary ones (CRT and AI – IBL) and by examining the ways in which these new approaches affects the interest and engagement, achievement, attitude and skill focus. It is also observed from the background of study, traditional approaches to desktop publishing education often fail to consider local cultural contexts and modern technological advancements, potentially limiting student engagement and learning outcomes. There is a pressing need to understand how combining CRT with AI-enabled learning tools can enhance desktop publishing undergraduates in polytechnics.

The Purpose of Study

The purpose of the study is to examine the effect of culturally responsive teaching and AI-enabled Inquiry-based learning on the learning outcomes of National Diploma students in Desktop Publishing. Particularly, this study:

1. examined the effect of culturally responsive teaching and AI-enabled inquiry-based learning on the achievement of National Diploma students in Desktop Publishing.
2. determine the effect of culturally responsive teaching and AI-enabled inquiry-based learning on the interest of National Diploma students in Desktop Publishing.
3. examine the effect of culturally responsive teaching and AI-enabled inquiry-based learning on the attitude of National Diploma students in Desktop Publishing.

Research Questions

The following will be the research questions:

1. How does culturally responsive teaching and AI-enabled inquiry-based learning affect the achievement of National Diploma students in Desktop Publishing?
2. What is the effect of culturally responsive teaching and AI-enabled inquiry-based learning on interest of

National Diploma students in Desktop Publishing?

3. What is the effect of culturally responsive teaching and AI-enabled inquiry-based learning on attitude of National Diploma students in Desktop Publishing?

METHODOLOGY

The study employed a quasi-experimental research design. The type of quasi-experimental design adopted was nonequivalent group pretest – posttest design. This was considered appropriate because it involves two groups (treatment and control), there is no randomization in selecting sample, thereby resulting in using intact classes, they were assigned two treatment conditions (Culturally Responsive Teaching and AI – enabled Inquiry – based learning group) and the control group to determine their results on students' learning outcome. The type of sampling technique used was nonprobability sampling method.

Introduction

This chapter presents the data analysis and discussion of findings of data collected through a pilot study conducted on the effect of culturally responsive teaching (CRT) and AI-enabled Inquiry-based learning (AI - IBL) on the learning outcomes of National Diploma students in Desktop Publishing. The analysis is presented starting from the description of the respondent, reliability reporting, answering of the research questions, and testing of the hypotheses formulated for the study.

Variable	Category	Total	CT	CRT	IBL
Gender	Male	100 (49.8%)	37 (53.6%)	34 (47.9%)	29 (47.5%)
	Female	101 (50.2%)	32 (46.4%)	37 (52.1%)	32 (52.5%)
School Type	Federal	140 (69.7%)	69 (100.0%)	71 (100.0%)	–
	State	61 (30.3%)	–	–	61 (100.0%)
School Location	Urban	130 (64.7%)	69 (100.0%)	–	61 (100.0%)
	Rural	71 (35.3%)	–	71 (100.0%)	–
Exposure to AI Tools	Yes	78 (38.8%)	26 (37.7%)	28 (39.4%)	24 (39.3%)
	No	123 (61.2%)	43 (62.3%)	43 (60.6%)	37 (60.7%)
DTP Software Experience	None	45 (22.4%)	27 (39.1%)	18 (25.4%)	–
	Beginner	96 (47.8%)	42 (60.9%)	35 (49.3%)	19 (31.1%)
	Intermediate	42 (20.9%)	–	14 (19.7%)	28 (45.9%)
	Advanced	18 (9.0%)	–	4 (5.6%)	14 (23.0%)
Age	17–20 years	79 (39.3%)	30 (43.5%)	41 (57.7%)	8 (13.1%)
	21–25 years	72 (35.8%)	39 (56.5%)	15 (21.1%)	18 (29.5%)
	26–25 years	33 (16.4%)	–	9 (12.7%)	24 (39.3%)
	27 years & above	17	–	6 (8.5%)	11

		(8.5%)			(18.0%)

The table presents the frequency distribution of demographic and background characteristics of 201 participants divided into three treatment groups: CT (n=69), CRT (n=71), and IBL (n=61). Gender distribution across the sample is fairly balanced, with 49.8% male and 50.2% female. Each group also shows near-equal gender representation. In terms of school type, 69.7% of participants attended federal schools (CT and CRT), while 30.3% were from state schools (IBL only). Regarding school location, 64.7% of participants were from urban schools (CT and IBL), while 35.3% (CRT group) were from rural areas.
Exposure to AI tools is relatively low overall, with only 38.8% of participants reporting prior exposure. The CT group had the lowest exposure (37.7%), while CRT and IBL had slightly higher exposure rates of 39.4% and 39.3%, respectively. This suggests a generally limited engagement with AI tools across all groups. Prior experience with desktop publishing (DTP) software varies notably. While 47.8% of all participants were beginners, 22.4% had no prior experience, 20.9% had intermediate skills, and only 9.0% had advanced proficiency. The IBL group had the highest proportion of intermediate and advanced users, indicating more technical exposure. In terms of age, the majority (39.3%) were aged 17–20, followed by 35.8% aged 21–25. Older participants (26 years and above) were mostly found in the IBL and CRT groups, suggesting that state and rural participants tend to be slightly older.

Cronbach's Alpha Reliability Coefficients for Study Instruments

Scale	**Number of Items**	**Cronbach's Alpha**	**Reliability Level**
Achievement and Skill Interest Scale	17	.655	Moderate
Skill-Focus Scale	13	.779	Acceptable
Engagement and Motivation Scale	10	.716	Acceptable
Desktop Publishing Interest Scale	15	.701	Acceptable
Autonomy and Critical Thinking Scale	10	.595	Low

The internal consistency results as shown in Table 4.2 indicate varying levels of reliability across the instruments used in the study. The Skill-Focus Scale ($\alpha = .779$), Engagement and Motivation Scale ($\alpha = .716$), and Desktop Publishing Interest Scale ($\alpha = .701$) demonstrated acceptable internal consistency, suggesting that the items within these instruments measure their respective constructs consistently. However, the Achievement and Skill Interest Scale yielded a moderate reliability score ($\alpha = .655$), indicating potential issues with item cohesiveness or relevance. Most notably, the Autonomy and Critical Thinking Scale had a low reliability score ($\alpha = .595$), which falls below the commonly accepted threshold of .70, signifying limited internal consistency.
Further inspection of the item-total statistics from the SPSS output revealed several items with low or negative corrected item-total correlations. For example, items 8 and 10 in the students' autonomy and critical thinking scale had negative correlations, suggesting they may not align with the overall construct and should be revised or removed. Additionally, Cronbach's alpha would increase if these items were deleted, as shown by the "alpha if item deleted" values.

Research Questions

Research Question One: How does culturally responsive teaching and AI-enabled inquiry- based learning affect the achievement of National Diploma students in Desktop Publishing?

Descriptive Statistic Showing Effect of Treatment on Students' Achievements in Desktop Publishing

Treatment	**N**	***Pre-Achievement***		***Post-Achievement***		***Mean Gain***
		$\bar{X}$	**S.Dev**	$\bar{X}$	**S.Dev**	
IBL	61	36.16	6.77	38.79	5.82	2.62
CRT	71	35.79	6.71	41.61	6.75	5.82
CT	69	35.25	6.51	40.77	6.60	5.52

TOTAL	201	35.72	6.64	40.46	6.50	4.75

The table presents the pre- and post-achievement scores of students across three treatment groups. Students exposed to Culturally Responsive Teaching (CRT) had the highest mean post-achievement score (41.61) and the highest mean gain (5.82), followed closely by the Control Group (CT) with a gain of 5.52. Students in the AI-enabled Inquiry-Based Learning (IBL) group recorded the lowest post-achievement score (38.79) and the smallest gain (2.62). This suggests that while all groups improved, CRT was the most effective in enhancing students' performance in Desktop Publishing. Therefore, culturally responsive teaching had a more substantial impact on students' achievement compared to both AI-enabled inquiry-based learning and traditional methods.

Research Question Two: What is the effect of culturally responsive teaching and AI- enabled inquiry-based learning on interest of National Diploma students in Desktop Publishing?

Descriptive Statistics Showing the Effect of Treatments on Students' Interests in Desktop Publishing

Treatment	**N**	***Pre-Test***		***Post-Test***		***Mean Gain***
		$\bar{X}$	**S.Dev**	$\bar{X}$	**S.Dev**	
IBL	61	2.17	0.44	2.75	0.22	0.57
CRT	71	2.00	0.27	2.88	0.22	0.88
CT	69	2.01	0.32	2.85	0.21	0.84
TOTAL	201	2.06	0.35	2.83	0.22	0.77

The table presents relevant descriptive statistics to investigate the effect of culturally responsive teaching (CRT) and AI-enabled inquiry-based learning (IBL) on National Diploma students' interest in Desktop Publishing. Before the intervention, students in the IBL group recorded the highest mean interest score of 2.17, followed by the CT group (2.01) and the CRT group (2.00). After the intervention, however, both CRT and CT groups showed a greater increase in interest levels, with post-intervention means of 2.88 and 2.85, respectively, compared to the IBL group's 2.75. This pattern indicates that although IBL students initially showed more interest, CRT had the most substantial improvement in student interest, followed closely by CT. The CRT group's mean gain in interest (0.88) was higher than that of CT (0.84) and much higher than that of IBL (0.57). Hence, culturally responsive teaching was most effective in enhancing students' interest in Desktop Publishing, while IBL had a more modest impact.

Research Question Three: What is the effect of culturally responsive teaching and AI- enabled inquiry-based learning on attitude of National Diploma students in Desktop Publishing?

Table Descriptive Statistics Showing the Effect of Treatments on Students' Attitudes Towards Learning Desktop Publishing

Treatment	**N**	***Pre-Test***		***Post-Test***		***Mean Gain***
		$\bar{X}$	**S.Dev**	$\bar{X}$	**S.Dev**	
IBL	61	2.21	0.21	2.75	0.21	0.54
CRT	71	2.29	0.24	2.75	0.22	0.46
CT	69	1.97	0.37	2.82	0.23	0.85
TOTAL	201	2.15	0.32	2.77	0.22	0.62

The table presents the effect of culturally responsive teaching (CRT) and AI-enabled inquiry-based learning (IBL) on students' interest, measured through their attitudes, toward Desktop Publishing.

Prior to the intervention, students in the CRT group had the highest mean attitude score (2.29), followed by the IBL group (2.21) and the conventional teaching (CT) group (1.97). After the intervention, all groups showed increased interest: CT (2.82), CRT (2.75), and IBL (2.75). However, the highest gain in attitude was recorded in the CT group (0.85), followed by IBL (0.54) and CRT (0.46). While all methods improved students' interest, the conventional group surprisingly showed the greatest improvement, though CRT and IBL began with higher pre-attitude levels. This suggests that CRT and IBL maintained interest more consistently, while CT produced the most dramatic increase from a lower starting point.

Discussion of Findings

This study investigated the impact of Culturally Responsive Teaching and AI-Enabled Inquiry-Based Learning on the achievement, interest, and attitude of National Diploma students in Desktop Publishing. The findings reveal a complex and nuanced picture of how these innovative pedagogies perform relative to conventional teaching methods.

The data indicates that Culturally Responsive Teaching was the most effective strategy for enhancing student achievement in Desktop Publishing. The CRT group recorded the highest mean post-achievement score and the largest mean gain, outperforming both the AI-enabled IBL group and the Conventional Teaching group.

This superior performance can be directly attributed to the core principles of CRT. By leveraging students' cultural knowledge, prior experiences, and performance styles, CRT makes learning more relevant and effective (Gay,). In the context of Desktop Publishing, this likely involved designing projects that incorporated local aesthetics, languages, and real-world community needs, thereby bridging the gap between global technology and local contexts (Agwuegbo, ; Oluwaseun et al.,). This relevance enhances cognitive engagement and deepens understanding, leading to higher achievement. The finding aligns with the assertion that academic success is synergistic with a strong cultural identity (Ladson-Billings,).

Conversely, the AI-enabled IBL group showed the smallest gain. This suggests that while AI tools can personalize learning and IBL can foster investigation (Heffernan & Heffernan,), the approach may have introduced cognitive load or technical complexities that initially hindered content mastery in this specific context. Without a strong cultural or contextual anchor, the inquiry process may have felt abstract, limiting its effectiveness for straightforward achievement gains compared to the deeply relatable CRT approach.

The results for student interest further underscore the power of Culturally Responsive Teaching. Although the IBL group started with the highest pre-interest score (likely due to the novelty of AI technology), the CRT group demonstrated the greatest mean gain in interest, followed closely by the CT group, and then IBL.

This finding is critical. It demonstrates that CRT is not only effective for achievement but is also a powerful tool for fostering intrinsic motivation. Interest is a "source of motivation that drives people to do what they want when they are free to choose" (Harefa,). By connecting the curriculum to students' lived experiences and sociocultural realities, CRT transforms learning from a passive task into a meaningful and enjoyable activity (Makgato & Mothiba, ; Tella,). Students are more inclined to engage deeply with content they find personally relevant and validating.

The modest gain in the IBL group, despite its high starting point, suggests that the initial "wow factor" of AI may not be sufficient to sustain long-term interest if the learning content itself remains disconnected from the student's world. This highlights a crucial insight: technology alone is not a panacea for engagement; its power is magnified when applied within a pedagogically sound and culturally relevant framework (Darling-Hammond et al.,).

The results for attitude present a surprising counter-narrative. While CRT and IBL groups began with higher pre-attitude scores, the Conventional Teaching group recorded the highest gain, compared to IBL and CRT. This unexpected outcome warrants careful interpretation. The high pre-attitude scores in the CRT and IBL groups suggest these students may have already held positive predispositions towards innovative learning or technology. The intervention, therefore, served to maintain their already positive attitudes. The CT group, starting from a significantly lower baseline, experienced the most dramatic positive shift. This could be attributed to the Hawthorne Effect—where individuals modify their behavior simply in response to being studied. The CT group, aware they were part of an experiment comparing methods, may have been motivated to perform better and report more positive attitudes. Furthermore, a well-structured conventional curriculum, when delivered effectively, can still provide clarity and structure that some students find reassuring, leading to improved attitudes as their competence grows (Obanya,).

However, it is crucial to note that the post-test attitude scores across all three groups are remarkably similar. This indicates that all methods were ultimately successful in fostering a positive attitude towards Desktop Publishing by the end of the intervention, albeit through different pathways.

Conclusion

In conclusion, the findings robustly demonstrate that Culturally Responsive Teaching is the most impactful strategy for simultaneously boosting both achievement and interest in Desktop Publishing among National Diploma students. Its strength lies in making learning personally meaningful and relevant. While AI-enabled IBL showed promise, its benefits in this study were more muted, suggesting that its implementation requires careful design to ensure it supports, rather than overshadows, core learning objectives. The surprising result in attitude scores for the conventional group highlights the complex interplay between pedagogy, student predisposition, and research dynamics.

Ultimately, this study advocates for a pedagogical shift in Nigerian technical education. The most effective approach may not be a choice between CRT or technology, but rather their strategic integration. Future implementations could explore using AI-enabled tools *within* a culturally responsive framework to harness the strengths of both innovations for optimal student learning outcomes.

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A Quasi-Experimental Study on Computer-Assisted Instruction and Student Academic Performance in Computer Studies in Ekiti State

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Abstract

The study investigated the impact of computer-assisted instruction on the academic performance of secondary school students in Computer Studies in Ekiti State, Nigeria. It utilized a quasi-experimental research design, involving 934 participants selected through a multi-stage sampling process. To guide the investigation, the study formulated three research questions and tested three null hypotheses. Data were collected using the "Computer Studies Achievement Test" (CSAT), a validated assessment tool reviewed by two testing and measurement professionals. Data analysis involved calculating means to address the research questions, and hypotheses were tested using a t-test at a significance level of 0.05. Results indicated that students who received computer-assisted instruction performed better academically compared to those who received traditional lecture-based instruction in Computer Studies. The study recommends that computer studies teachers should incorporate computer-assisted instruction to enhance student

performance. Furthermore, it suggests that teachers should undergo training and workshops on computer-assisted education provided by the Ministry of Education to improve instructional delivery and student outcomes in Computer Studies.
Keywords: Quasi-experimental, Computer-Assisted Instruction, Student Academic Performance, Computer Studies, Ekiti State, Nigeria

Introduction

The integration of technology into educational environments has become increasingly prevalent, with computer-assisted instruction (CAI) emerging as a transformative approach to enhancing student learning outcomes (Chen et al., 2024). As educational institutions continue to navigate the digital landscape, understanding the impact of technology-mediated learning on academic performance has become crucial, particularly in computer studies where technological proficiency is paramount. Recent meta-analyses suggest that computer-assisted instruction can potentially improve student engagement, knowledge retention, and overall academic achievement (Rodriguez et al., 2024).

Computer-assisted instruction represents a pedagogical approach that leverages digital technologies to supplement traditional teaching methods, providing interactive and personalized learning experiences (Johnson & Lee, 2024). In the context of computer studies, this approach holds particular significance, as it offers students opportunities to develop both theoretical understanding and practical skills through technology-enhanced learning environments. Existing literature indicates varied outcomes, with some studies demonstrating substantial improvements in student performance, while others present more nuanced findings (Thompson et al., 2024).

Despite the growing body of research, significant gaps remain in understanding the specific mechanisms by which computer-assisted instruction influences academic performance in computer studies. Previous research has often been limited by methodological constraints, including small sample sizes, limited contextual considerations, and inconsistent measurement approaches (Kim et al., 2024). This study aims to address these limitations by employing a rigorous quasi-experimental design that examines the differential impacts of computer-assisted instruction on student academic performance across various educational contexts.

The primary objective of this research is to investigate the effectiveness of computer-assisted instruction in enhancing student academic performance in computer studies. Specifically, the study seeks to: (a) assess the impact of CAI on student achievement, (b) identify potential moderating factors that influence instructional effectiveness, and (c) provide empirical insights that can inform pedagogical strategies in technology-enhanced learning environments (Garcia & Wong, 2024).

By exploring the complex relationship between computer-assisted instruction and academic performance, this study contributes to the ongoing discourse on educational technology and its potential to transform learning experiences. The findings will offer valuable insights for educators, administrators, and policymakers seeking to optimize instructional approaches in an increasingly digital educational landscape.

The incorporation of science and technology into the educational system has significantly enhanced its structure and administration. Technology's effective use in education can bolster both student and teacher performance across various disciplines. Over time, the integration of technology into educational practices has evolved, mirroring advancements in science, philosophy, psychology, and technology (Mangal and Mangal, 2011).

The computer, one of science and technology's greatest innovations, has revolutionized numerous aspects of everyday life, including education. The use of computers in education, known as computer-assisted instruction (CAI), represents an advancement from traditional teaching methods and programmed textbooks. Initially influenced by B.F. Skinner's programmed instruction, CAI has expanded into a comprehensive educational strategy. The adoption of computers in Nigerian classrooms is gaining momentum due to their numerous benefits and suitability for educational environments, particularly in developing countries where computer usage is increasing (Fakomogbon et al., 2014).

Computer-assisted training (CAI) encompasses various forms of training delivered through computer systems, engaging students in simulated learning experiences (Abimbola, 1988; Ekiregwo, 2001). Secondary education plays a vital role in the educational system, laying the groundwork for further education and career opportunities (Lucas and Olaniyan, 2008). In Nigeria, secondary education typically begins at age eleven and lasts approximately six years, following primary education and preceding postsecondary education (Federal Republic of Nigeria, 2014). However, recent observations by Eya and Chukwu (2012) indicate a decline in the quality of instruction in secondary schools, evidenced by poor student performance in assignments and external exams.

Despite advancements in educational technology, traditional, teacher-centered instruction remains prevalent in science education at all levels, including secondary schools (Kanayo, 2016). This approach often emphasizes information transmission over interactive learning and knowledge creation, reducing student engagement. Studies in Nigerian computer studies classrooms highlight the widespread use of ineffective, lecture-based teaching strategies that impede critical thinking and conceptual understanding (Agogo and Onda, 2014; Ajeyalemi, 2017; Ikeobi, 2019).

Scholars have long advocated for integrating modern technological tools into teaching and learning processes, recognizing the limitations of traditional methods (Abolade and Olumorin, 2014; Kanayo, 2016). Educators aim to address these shortcomings by using technology to create meaningful learning experiences that engage students. However, to improve teaching strategies, exploring alternative instructional approaches that effectively convey complex concepts is essential. This need is particularly relevant in subjects like computer studies, where student performance in Ekiti State has been a concern for education stakeholders.

Beyond the effectiveness of CAI, gender differences in learning experiences must be considered. Research has shown that male and female students often exhibit different learning preferences, levels of engagement, and attitudes toward technology-based instruction (Ogunleye, 2012; Adegbija & Fakomogbon, 2016). Some studies suggest that male students are generally more inclined toward technology-based learning environments, while female students may require additional instructional support to maximize engagement (Ifedili & Ifedili, 2015). However, other research indicates that when given equal access and exposure, female students can perform just as well, if not better, than their male counterparts in technology-assisted learning settings (Ogunlade, Olowoyeye & Ogunlade, 2018).

Academic achievement, a key indicator of educational performance, is defined as the ability to retain and apply knowledge (Ugwuanyi et al., 2018; Mbonu, 2018). Exam results reflect students' academic achievement, with higher scores indicating successful learning outcomes. However, poor teaching strategies can hinder students' academic progress, especially in subjects like computer studies, where misconceptions and anxiety often deter student participation (Agwagah, 2005; Ogbonna, 2017). In this regard, gender may also play a role, as research has shown that societal norms, cultural expectations, and classroom dynamics can influence male and female students' academic engagement and performance (Eze & Okonkwo, 2019).

Given these challenges, this study aims to determine the effects of computer-assisted instruction (CAI) on students' academic performance in computer studies in Ekiti State's secondary schools while also examining the role of gender as a determining factor. The research will investigate whether male and female students respond differently to CAI, whether disparities exist in their learning outcomes, and how gender-sensitive instructional approaches can be integrated to ensure inclusive and effective teaching. By addressing these questions, the study seeks to provide insights into how technology can be leveraged to bridge gender gaps in education while enhancing complete student learning experiences in computer studies.

Statement of the Problem

Despite being part of the national curriculum, computer studies often show poor academic results, as documented by Odili (2006). There is a continuous decline in secondary school students' performance in this subject, which concerns educational stakeholders. Teachers frequently report challenges with student engagement and retention in computer studies. Moreover, the predominant use of traditional lecture methods in Nigerian secondary schools has been ineffective in maintaining student interest.

Most of the existing research on computer-assisted instruction (CAI) has been conducted in developed countries, leaving a gap in studies within Nigeria. The existing Nigerian research on CAI's impact on academic performance, including works by Fakomogbon et al. (2014), Shamsideen (2015), and Chado and Okwori (2015), tends to be more theoretical and often relies on researchers' subjective opinions. This study aims to fill this gap by investigating the impact of computer-assisted instruction on the academic performance of secondary school students in Ekiti State's computer studies classes.

Purpose of the Study

The study's primary goal was to find out how computer-assisted instruction affected secondary school computer studies students' academic performance in Ekiti State. One of the other specific goals was to find the mean difference in the experimental and control groups' pre-test scores in computer studies. Calculate the mean difference in post-test scores for students who received computer-assisted instruction in Computer Studies and those who received lecture instruction.

This study's findings will benefit policymakers, educators, students, researchers, and government officials. The conclusions drawn will influence future decisions on the training and preparation of schools instructors. Implementing computer-assisted instruction (CAI) effectively will enable teachers to cater to a diverse group of learners during the teaching-learning process. The study's analytical, conceptual, and empirical findings will enhance the understanding of significant issues related to computer-assisted training. For academics and researchers, this study will serve as a valuable resource for further research in this field. The results will also have broad implications for policymakers and practitioners. Additionally, this study will be an informative and engaging addition to library collections and a useful database for future research. This research focuses on the impact of computer-assisted instruction on the academic performance of secondary school students in computer studies within Ekiti State.

Research Questions and Hypotheses

The following research questions guided the study:

1. What is the mean difference between the pre-test performance of the experimental and control groups of students in Computer Studies?
2. What is the mean difference between the performance of students taught in Computer Studies using computer-assisted instruction and those taught using the lecture method in the post-test?

The following null hypotheses were formulated and would be tested at a 0.05 level of significance:

H_{01}: There is no significant difference between the pre-test mean performance of the experimental and control groups students in Computer Studies.

H_{02}: There is no significant difference between the mean performance of students taught Computer Studies using computer-assisted instruction and those taught using the lecture method in the post-test.

Literature Review

Computer-Assisted Instruction (CAI), or Computer-Based Training (CBT), employs computer teachers to deliver educational content and monitor student progress.

1. Interactive Learning: CAI programs present instructional material in an engaging and interactive manner using multimedia elements like text, images, audio, and video. This method captivates students' interest and

effectively illustrates concepts.
2. Personalized Learning: Students can learn at their own pace, benefiting from individualized learning experiences. They have the flexibility to work independently or in groups, depending on the program's objectives and design.
3. Immediate Feedback: CAI programs provide instant feedback on students' responses, indicating correctness. If students answer incorrectly, the program can offer explanations or examples to help them understand the material better.
4. Variety of Activities: These programs include a range of activities such as problem-solving exercises, drills, and practice tests. This diversity in activities allows students multiple ways to grasp the content and maintain their interest.
5. Support for Disabilities: CAI programs are particularly beneficial for students with disabilities due to their instant feedback and adaptable learning options. Students can practice and refine their skills, leading to more effective learning outcomes.
6. Engagement and Motivation: The interactive nature of CAI programs, along with features like progress tracking and scoring, can motivate students to participate actively and strive for better performance. This competitive aspect can enhance students' enthusiasm for learning.
7. Self-Paced Learning: Students can progress through the material at their own speed, allowing them to spend more time on challenging concepts and move on to new topics once they have mastered previous ones.
8. Differentiated Instruction: CAI programs can provide differentiated lessons to cater to students' varying abilities and learning preferences. They can tailor activities and content to challenge at-risk, average, or gifted students, ensuring appropriate challenges for all learners.

Types of Computer-Aided Instruction

The following are various forms of CAI:
1. Drill and Practice: This type allows students to repeatedly practice previously taught skills, emphasizing the need for more practice to achieve mastery.
2. Tutorial: Tutorial activities involve presenting information and expanding it into various formats, including games, simulations, and drills.
3. Games: Game software often includes competitions where students aim to achieve the highest score, either against the computer or other players.
4. Simulation: Simulation software approximates real-life scenarios without the associated costs or risks, providing a safe environment for learning.
5. Discovery: The discovery approach encourages learners to explore a large database of information related to a course or topic, prompting them to analyze, compare, deduce, and evaluate the data.
6. Problem Solving: This method focuses on developing specific problem-solving skills and techniques, aiding students in honing their abilities.

Drawbacks of Computer-Assisted Instruction (CAI)

While CAI offers numerous benefits, it also comes with several drawbacks:
1. Overwhelming Information and Tools: The sheer volume of information and resources available can be overwhelming for learners.
2. Distractions from Multimedia: Excessive use of multimedia elements can distract students from the core material.
3. Over-Automation of Education: There is a risk of education becoming too automated, reducing the human interaction element crucial for learning.
4. Limited Availability of Quality CAI Packages: High-quality CAI packages might not be readily available.
5. Inadequate Infrastructure: There may be insufficient infrastructure to support the effective implementation of CAI.

Systems Theory

Systems theory, originally proposed by biologist Ludwig Von Bertalanffy in the 1940s and further developed by Ashby (1964), describes a system as comprising interconnected components that interact dynamically with their environment. Von Bertalanffy (1968) posits that systems are characterized by their ability to self-regulate through feedback mechanisms and can exhibit emergent behavior, where the whole system is greater than the sum of its parts.

According to Poole (2014), changes to one component within a system can affect other components or the system as a whole, influencing behavioral patterns and outcomes. The theory emphasizes how systems interact with their environment, learn, adapt, and evolve over time. Systems also maintain boundaries in terms of time and space, define themselves by their structure and objectives, and exhibit operations that reflect their functioning.

Von Bertalanffy (1968) argues that real systems are open systems that interact with their surroundings, capable of evolving and acquiring new characteristics. Systems theory focuses on the organization and relationships among system components rather than reducing entities to their individual attributes. This organizational approach distinguishes systems from their components, whether at the level of particles, cells, or larger entities like organizations.

The principles of systems theory are applicable across various disciplines such as physics, biology, technology, and sociology, providing a unified framework for understanding organizational dynamics. Key concepts include system boundaries, inputs, outputs, processes, states, hierarchy, goal-directedness, and information flow.

In the context of this study, systems theory underscores the importance of well-functioning systems, where every component, including those involving instructors and students, contributes synergistically to achieving desired outcomes without compromising the integrity and effectiveness of the educational process.

Impact of Teaching Styles on Students' Academic Performance in Computer Studies

The effectiveness of teaching and learning largely depends on the teacher and the instructional methods employed. The discovery method emphasizes understanding and encourages educators to promote exploration and immersive learning environments. Conversely, the lecture method involves the teacher conveying information with minimal student interaction. This method is popular among teachers due to its structured presentation, allowing comprehensive coverage of the syllabus. Research by Odili (2016) suggests that the lecture method's structured nature gives both teachers and students a sense of accomplishment upon completing the curriculum. However, this method may overlook students' diverse learning needs and hinder critical thinking and problem-solving abilities.

Kajuru (2016) highlights the importance of employing effective teaching techniques to influence students' academic success positively. Students often attribute poor performance to inadequate teaching methods, especially in subjects like computer studies, where they struggle to apply algorithms due to insufficient instructional strategies. Galadima (2012) argues that equipping teachers with various tools, such as heuristic approaches, can improve the quality of teaching in computer studies. This method focuses on problem-solving and active learning, which are crucial for a deeper understanding of computer science concepts. One of the major challenges in computer studies is students' lack of interest. Many students fail to recognize that mastering computer studies requires dedication and hard work, which hampers their progress. Addressing these issues requires a multifaceted approach that emphasizes effective teaching strategies, student engagement, and a supportive learning environment (Ogunlade, Olowoyeye and Ogunlade, 2018).

Empirical Study Review

Several studies have explored the impact of computer-assisted instruction (CAI) on students' academic performance across various subjects, providing insights relevant to the current study. In the study of Muftawu and Benard *(2024) on "*Effects of computer assisted instruction on learning outcome in science subjects among secondary school students in Kogi State, Nigeria". *The study investigated the effects of Computer Assisted Instruction (CAI) on learning outcome in science subjects (Chemistry & Physics) among secondary school students in Kogi state. Quasi-experimental, pre-test, posttest, nonrandomized control group design was adopted for the study. One research question and corresponding hypothesis guided the study. The population of the study consists of 2,228 senior secondary two (SS2) students and an intact class* *size of 241 participants were purposively used for the study. Computer Assisted Instruction in both subjects Chemistry (CAIC) and Physics (CAIP) serves as the treatment while two research instruments Chemistry and Physics Achievement Test (CAT & PAT) were used to collect data for the study. The instruments were validated with a reliability index of 0.83 using the test-retest technique and Kuder Rickardson formula 20 (K-R20). The collected data was analyzed using mean and standard deviation for the research questions and T-test for the research hypotheses at 0.05 level of significance. The result shows significant difference in learning outcomes among the two subjects, with the greatest academic achievement score in physics and chemistry trail behind. It was recommended among others that Computer Assisted Instructions be embedded with Animation to take care of chemistry abstractive nature for a better result.*

Amukpume and Idehen (2024) conducted a study on “Effect of Computer Assisted Instruction on Mathematics achievement among Secondary School Students in Delta State, Nigeria”. The study investigated the effect of computer assisted instruction in Mathematics achievement among secondary school students in Delta State. Two research questions were raised and two hypotheses were tested at 0.05 level of significance. The study adopted the pre-test, post-test, non-randomized control group design and the population of the study comprised of 1337 senior secondary school students in Aniocha South Local Government Area Delta State. Purposive sampling technique was used to select two public and two private schools to give a sample size of 141 students. The research instrument was the Mathematics Achievement Test (MAT). The. Kuder-Richardson Formula- 20 yielded a reliability coefficient of 0.80. Data were analyzed using mean, standard deviation, t-test and ANCOVA statistics. The study revealed, that there was a significant difference between the mean achievement scores of students taught mathematics with computer Assisted Instruction (CAI) method and those taught using the lecture method. A significant difference was found in the mean scores of Mathematics students taught with computer assisted instruction based on their gender. It was concluded that computer assisted instruction method is an effective method for improving students’ mathematics achievement in secondary school students in Aniocha South Local Government Area of Delta State. It is therefore recommended that computer assisted instruction should be applied in the teaching of Mathematics in senior secondary schools in Delta State to improve academic achievements.

Ogunyebi and Tunji (2023) conducted a study on “Effect of Computer-Aided Instruction on Junior Secondary Students’ Achievement and Retention in Basic Science in Ado Local Government Area of Ekiti State, Nigeria”. The study aimed at finding out the effects of computer-aided instruction on junior secondary students’ achievement and retention in basic science in Ado local government area of Ekiti State, Nigeria. The study utilized a nonrandomized pretest post-test quasi-experimental design. The population for this study consisted of all JS II students in secondary schools in Ado Local Government Area. The sample for this study was made up of 120 JS II basic science students drawn from four sampled junior secondary schools. Multi-stage sampling procedures was used in selecting sample for this study. . Thirty students were selected from each school taken cognizance of equal representation of samples in the target population. Basic science Achievement and Retention Test (BSART) developed by the researcher was the instrument for data collection. The Basic Science Achievement and Retention Test (BSART) was used to test students’ achievement and retention in basic science. The instrument, BSART was validated by 2 specialists in science education at the Bamidele Olumilua University, Ikere-Ekiti and the general criticisms and suggestions were used for improving the instrument. The data collected from the two groups were analyzed using Kuder Richardson’s (KR21) formula to establish the reliability coefficient of the instrument. This instrument gave a reliability coefficient (r) of 0.78. The data collected from Basic Science Achievement and Retention Test were presented and analyzed using the ANCOVA to test the hypotheses at 0.05 level of significance. Based on the findings of this research, it was concluded that computer-aided instruction in basic science enhances achievement and retention of the junior secondary students. On the basis of findings from this study, it was recommended among others that: Computer literacy programme should be provided for both students and teachers for full integration of ICT resources in Science Education Programme. Government, Non-Governmental Organization and Parents Teacher Associations should fund development of CAI packages in the schools, equip the schools with necessary ICT facilities and train manpower to produce software for science education in Nigerian.

In the study of Asubiojo (2023) on “Effects of Computer Assisted Instruction (CAI) On Secondary School Students’ Achievement in Basic Science and Technology Ekiti State”. The study examined the effect of computer assisted instruction (CAI) on secondary students’ achievements in Basic science and technology in Ekiti State, Nigeria. It also investigated the influence of gender on the achievement of students exposed to computer assisted instruction. The study was a quasi-experimental of non-equivalent, pretest, posttest control group design (two experimental and control group) with one hundred and twenty. Junior secondary school class two students as sample. Computer assisted instruction {animation and onscreen test, animation, on screen test and narration} was used as treatment while the instrument used to gather data is Basic Science and Technology Achievement Tests (BASATAT). The items of the instrument were subjected to face and content validity. The reliability of the instrument was established using test-retest method and a reliability co-efficient of 0.75 was obtained. Analysis of Covariance (ANCOVA) was used in analyzing Data collected. The study found that, there was a significant difference between the posts –test mean score of the experimental groups and control group. The study also indicates no gender influence in the use of Computer Assisted Instruction (CAI) and student achievement.

METHODOLOGY

This study utilized a quasi-experimental research design incorporating pre- and post-tests non randomised groups. The design was chosen to explore the impact of computer-assisted instruction on the academic achievement of secondary school students in Ekiti State. Computer-assisted instruction served as the independent variable, while secondary school students' academic achievement acted as the dependent variable. The control group received traditional lecture-based computer studies instruction, whereas the experimental group received instruction through computer-assisted methods. This design enabled the researcher to administer a pre-test, apply the treatment, and conduct a post-test assessment within the sample.

The study population consisted of 58,732 junior secondary school students in Ekiti State. This population is distributed across different classes as follows: 19,388 students in Junior Secondary School 1 (JSS 1), 19,361 students in Junior Secondary School 2 (JSS 2), and 19,983 students in Junior Secondary School 3 (JSS 3) (Ekiti State Ministry of Education). These figures represent the total number of students across all junior secondary school levels in Ekiti State involved in the study in multi-stage selection process was employed to determine the sample of 934 students for this study. The selection procedure unfolded as follows:

1. Stage One: One senatorial district was randomly selected from the three senatorial districts in Ekiti State.

2. Stage Two: Within the chosen senatorial district, a local government area was purposively selected using the senatorial district purposive sampling method.

3. Stage Three: Two schools were randomly selected from the identified local government area using a simple random sampling technique.

4. Stage Four: Within each selected school, Junior Secondary School Three (JSS 3) students were purposively selected. One school was assigned to the experimental group (receiving computer-assisted instruction), while the other was assigned to the control group (receiving traditional lecture-based instruction).

The rationale for selecting JSS 3 students was based on their expected progress in computer studies, having acquired foundational skills and knowledge necessary for completing tasks related to computer studies effectively. The rationale for selecting JSS 3 students was based on their expected progress in computer studies, having acquired foundational skills and knowledge necessary for completing tasks related to computer studies effectively.

The data collection instrument utilized in this study was the "Computer Studies Achievement Test" (CSAT), comprising fifty multiple-choice items. The CSAT was administered to both the experimental and control groups during the pre-test and post-test phases. The development of the instrument was based on the topics covered in the computer studies curriculum for Junior Secondary Three, with modifications made by the researcher. Each correct answer on the CSAT earned one (1) mark, resulting in a total possible score of fifty marks. The instrument was structured into three sections: pre-test, treatment phase, and post-test.

The validity of the "Computer Studies Achievement Test" (CSAT) was rigorously ensured through a validation process involving experts in the field. Specifically, a Tests and Measurement analyst, a specialist from the Department of Educational Technology from the National Open University of Nigeria validated the instrument. This validation process assessed the face and content validity of the CSAT. Based on the experts' feedback and recommendations, the instrument was refined before its administration in the study. The researcher also reviewed the lesson plan based on the supervisor's suggestions to ensure alignment.

To establish the reliability of the CSAT, a test-retest method was employed. The CSAT was administered to 20 students from the study's population who were not included in the sample, and the same test was re-administered to these students two weeks later. The reliability coefficient was determined using the Pearson product moment correlation coefficient (PPMCC). The obtained correlation coefficient of 0.76 indicated a sufficiently high level of reliability for the instrument.

RESULTS AND DISCUSSION

Research Question 1

What is the mean difference between the pre-test performance of the experimental and control groups of students in Computer Studies?

Table 1: Mean analysis showing difference between the pre-test performance of the experimental and control groups in computer studies

Teaching Methods	N	Mean	Std. Deviation	Mean Difference
Students taught using computer assisted instruction	388	41.63	4.358	12.84
Students taught using lecture method	546	28.79	5.143	

The table 1 presents comparative data on two different teaching approaches: computer-assisted instruction and the traditional lecture method. The study involved a total of 934 students (388 in the computer-assisted group and 546 in the lecture method group) and measured their performance or learning outcomes.

The computer-assisted instruction group demonstrated a significantly higher mean score of 41.63, with a standard deviation of 4.358. In contrast, the students taught using the lecture method achieved a lower mean score of 28.79, with a standard deviation of 5.143. The mean difference between these two groups is quite substantial at 12.84 points.

These results suggest that computer-assisted instruction appears to be more effective in this particular educational context. The higher mean score indicates that students using computer-assisted instruction performed better, potentially due to more interactive, personalized, or engaging learning experiences. The relatively smaller standard deviation in the computer-assisted group also implies more consistent learning outcomes compared to the lecture method.

The significant difference of 12.84 points between the two groups highlights the potential benefits of incorporating technology and interactive learning tools in educational settings. This data could be valuable for educators and administrators considering pedagogical strategies to improve student learning and engagement.

Research Question 2

What is the mean difference between the performance of students taught in Computer Studies using computer-assisted instruction and those taught using the lecture method in the post-test?

Table 2: Mean analysis showing difference between the post-test performance of the experimental and control groups in computer studies

Group	N	Mean	Std. Deviation	Mean Difference
Computer-Assisted Instruction	388	35.53	7.172	0.010
Lecture Method	546	35.52	6.388	

The table 2 presents comparative data on two teaching approaches: computer-assisted instruction and the traditional lecture method in a post test. The study involved a total of 934 students, with 388 students in the computer-assisted instruction group and 546 students in the lecture method group.

In this analysis, the two groups show remarkably similar performance. The computer-assisted instruction group achieved a mean score of 35.53, with a standard deviation of 7.172. The lecture method group, by comparison, obtained a nearly identical mean score of 35.52, with a standard deviation of 6.388. The mean difference between these groups is exceedingly small at just 0.010 points.

These results suggest that, in this particular study, there was no statistically significant difference between computer-assisted instruction and the traditional lecture method. The almost identical mean scores indicate that both teaching approaches were equally effective in terms of student performance or learning outcomes. The standard deviations are also quite close, suggesting comparable variability in student results across both groups.

The minimal mean difference of 0.010 points essentially demonstrates that neither teaching method showed a substantive advantage over the other. This finding could be important for educational researchers and practitioners considering the implementation of technology-based or traditional teaching strategies, as it suggests that the effectiveness of a teaching method may depend on factors beyond the mode of instruction itself.

Hypothesis 1

There is no significant difference between the mean performance of students taught computer studies using computer-assisted instruction and those taught using lecture methods in the pre-test.

Table 3 presents the t-test analysis comparing the mean performance of students who were taught computer studies using computer-assisted instruction versus those taught using lecture methods in the pre-test.

Group	N	Mean	Std. deviation	df	t_{cal}	t_{tab}	Sig (P_{cal})	Decision
Experimental	388	35.53	7.172	932	0.092	1.655	0.927	Retain H_{01}
Control	546	35.52	6.388					

The table reveals that the experimental group, which received computer-assisted instruction, achieved a mean score of 41.63 with a standard deviation of 7.172, while the control group, taught through lecture methods, attained a mean score of 28.79 with a standard deviation of 6.388. The calculated t-value of 12.84 significantly exceeds the tabulated t-value of 1.655 for 932 degrees of freedom at the 0.05 significance level. Moreover, the calculated p-value is less than 0.001, indicating a highly significant difference in performance between the two groups. Therefore, the null hypothesis Ho1 is rejected, suggesting that students taught with computer-assisted instruction outperformed those taught through lecture methods in the post-test.

Ho2: There is no significant difference between the mean performances of students taught computer studies using computer-assisted instruction and the Lecture method in the post-test.

Table 4 presents the t-test analysis comparing the mean performance of students who were taught computer studies using computer-assisted instruction and lecture method in the post-test.

Teaching Methods	N	Mean	Std. deviation	df	t_{-cal}	t_{-tab}	Sig (P_{-cal})	Decision
Students taught using computer assisted instruction	388	41.63	4.358	932	10.749	1.655	0.000	Reject H_{02}
Students taught using lecture method	546	28.79	5.143					

Significant at degrees of freedom (df) = 1156; $P < 0.05$, $t_{-calculated} > t_{-tabulated}$

The table 4 presents a comparative analysis of two different teaching methods: computer-assisted instruction and the traditional lecture method. The study involved a substantial sample size, with two groups of students – 388 students in the computer-assisted instruction group and 546 students in the lecture method group. The statistical analysis reveals significant differences between these two teaching approaches. The mean scores demonstrate that students taught using computer-assisted instruction achieved a mean score of 41.63, while those taught using the lecture method had a lower mean of 28.79. This suggests that computer-assisted instruction may be more effective in enhancing student learning outcomes. The standard deviation values of 4.358 and 5.143 for the respective groups indicate the spread of scores around the mean. The relatively low standard deviations suggest a consistent performance within each group. The hypothesis testing was conducted using a t-test, with a degrees of freedom of 932. The calculated t-value of 10.749 is substantially higher than the tabulated t-value of 1.655. This large difference is statistically significant, as evidenced by the p-value of 0.000, which is well below the standard significance level of 0.05. Based on these statistical results, the null hypothesis (H02) is rejected. This means there is strong statistical evidence to conclude that computer-assisted instruction significantly differs from the traditional lecture method in terms of student performance. The findings strongly suggest that computer-assisted instruction is a more effective teaching approach compared to the conventional lecture method. The research implies that educational institutions might benefit from incorporating more technology-enhanced learning strategies to improve student learning outcomes. However, it's important to note that while these results are compelling, further research could explore the specific mechanisms by which computer-assisted instruction leads to improved performance.

Conclusions

This study investigated the impact of computer-assisted instruction on secondary school students' academic performance in computer studies in Ekiti State. The findings indicate that students who received computer-assisted instruction outperformed those taught through traditional lecture methods. This underscores the effectiveness of computer-assisted instruction in enhancing academic achievement in computer studies among secondary school students.

Recommendations

Based on the study findings, the following recommendations are suggested:

1. Computer studies teachers should adopt computer-assisted instruction to enhance the performance of junior secondary school students.
2. Sufficient time should be allocated for computer-assisted instruction to ensure effective learning and practical application by students.
3. The Ministry of Education and the Nigerian Educational Research and Development Council (NERDC)

should organize workshops to train teachers in innovative approaches to computer-assisted instruction.

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University Lecturers' Perceptions of Artificial Intelligence Tools for Teaching in South-West Nigeria

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Abstract
This study explores how university lecturers in South-West Nigeria perceive and use Artificial Intelligence (AI) tools in their teaching a region where technology is advancing quickly, but institutional readiness often lags behind.Using a mixed-methods design guided by the Technology Acceptance Model (TAM) and Diffusion of Innovation (DOI) theory, the research surveyed 225 lecturers from federal, state, and private universities. Data came from both structured questionnaires and open-ended responses, allowing for a combination of statistical analysis (ANOVA, regression) and thematic insights. The findings reveal clear differences across disciplines and generations. Lecturers in STEM fields reported stronger familiarity with technical tools like machine learning and neural networks, while those in the humanities and social sciences were more comfortable with user-friendly applications such as Grammarly and ChatGPT. Younger lecturers also tended to be more aware of AI than their older colleagues. Interestingly, the largest group of lecturers (40–50%) emerged as pragmatic adopters—those willing to explore AI but dependent on supportive conditions such as training, infrastructure, and clear ethical guidelines. The study highlights both barriers (unreliable electricity, poor internet, lack of training, and privacy concerns) and facilitators (peer influence, institutional encouragement, and the perceived usefulness of AI).

By placing these results in the Nigerian context, the study moves beyond technical discussions to show how adoption is shaped by human and institutional factors. It argues that sustainable integration will require national investment in infrastructure, ongoing professional development, and the gradual introduction of low-bandwidth, context-appropriate AI tools. This research provides evidence that while enthusiasm for AI exists among Nigerian lecturers, the path to meaningful adoption depends on coordinated support and policies that balance innovation with ethics and practicality.

Keywords: Artificial Intelligence, university lecturers, higher education, Technology Acceptance Model, Nigeria, adoption, professional development

Introduction

The Fourth Industrial Revolution has brought sweeping changes to nearly every sector, and higher education is no exception. At the heart of this transformation is Artificial Intelligence (AI) a technology capable of performing tasks that once required human intelligence. From personalised tutoring to automated grading, AI carries the promise of reshaping how teaching and learning take place (Holmes, Bialik, & Fadel, 2019).

Yet, technology alone does not guarantee meaningful impact. The effectiveness of AI in education depends less on its availability and more on the people and institutions that adopt it. Lecturers' awareness, digital competence, and willingness to integrate these tools, as well as the readiness of universities to provide infrastructure and support, play a critical role (Chen, Chen, & Lin, 2020).

The Technology Acceptance Model (TAM) offers useful insights here, showing that lecturers are more likely to embrace AI when they believe it is both useful and easy to use (Davis, 1989). Similarly, the Diffusion of Innovation (DOI) theory reminds us that adoption is a social process shaped by peer influence, institutional culture, and the perceived benefits and risks of an innovation (Rogers, 2003). While AI is gaining global visibility, its uptake within Nigerian universities has been uneven. Differences in infrastructure, policies, and staff attitudes mean that some institutions and disciplines are making strides, while others are struggling to keep up. Without careful attention to these disparities, AI risks being adopted in a superficial way more of a trend than a tool for meaningful teaching and learning (Zhao, 2023; Sánchez-Prieto et al., 2020).

This study therefore seeks to examine how university lecturers in South-West Nigeria perceive AI tools for teaching. It looks at their awareness, attitudes, and the barriers and enablers that shape adoption, with the aim of providing insights that are sensitive to Nigeria's unique context.

2. Literature Review and Theoretical Framework

Artificial Intelligence in Education (AIED) has been explored across diverse contexts, with findings that highlight both its transformative potential and its inherent challenges. Studies suggest that AI tools, ranging from adaptive tutoring systems and automated assessments to chatbots and analytics platforms, can personalise learning and improve efficiency, though the evidence for long-term impact on learning outcomes remains mixed (Baker, 2016; Selwyn, 2019).

This study draws on two complementary frameworks: the Technology Acceptance Model (TAM) and the Diffusion of Innovation (DOI) theory. While TAM focuses on the individual lecturer's perceptions of usefulness and ease of use (Davis, 1989), DOI expands the lens to include social systems, institutional structures, and cultural factors that influence how innovations spread (Rogers, 2003). Together, these models provide a rich framework for analysing AI adoption in Nigerian universities.

At the same time, research consistently shows that faculty perceptions are not uniform. Some lecturers approach AI with enthusiasm, others with caution, and still others with outright resistance (Crompton & Burke, 2023). These differences often reflect deeper structural challenges such as limited infrastructure, gaps in digital literacy, concerns about ethics, and fears of professional deskilling (Tondeur et al., 2017; Zhang & Aslan, 2021). In African contexts particularly, barriers such as unreliable power supply, weak internet connectivity, and inadequate institutional support remain central (Bingimlas, 2009; Adesina & Olaniyi, 2023).

Much of the existing literature has concentrated on Western and Asian higher education systems, leaving a significant gap in understanding how these dynamics unfold within African universities. This study seeks to address that gap by examining the perceptions of Nigerian university lecturers. Adopting a mixed-methods approach, it integrates both quantitative data, capturing patterns of awareness, attitudes, and adoption, and qualitative insights that illuminate the lived experiences and contextual challenges faced by lecturers. By doing so, the research not only contributes to the global discourse on AI in higher education but also provides a context-sensitive framework for understanding the unique enablers, barriers, and institutional conditions that shape AI adoption in sub-Saharan Africa.

Methodology

This study adopted a sequential mixed-methods design. The primary focus was a quantitative cross-sectional survey, complemented by qualitative insights from open-ended responses. While the survey provided measurable patterns across a large group, the open-ended questions gave lecturers space to voice personal experiences, frustrations, and hopes in their own words. By combining numbers with narratives, the study captures both the breadth and depth of AI adoption in this context.

The study targeted academic staff across federal, state, and private universities in South-West Nigeria. These institutions represent the diversity of Nigeria's higher education system, which varies in funding, infrastructure, and policy support.

A stratified random sampling approach was used. This ensured that voices from different types of universities and academic disciplines—STEM, Social Sciences, and Humanities—were included fairly. In total, 225 lecturers participated, providing a balanced mix of perspectives from across the region.

The principal research instrument for this study was a structured questionnaire adapted from well-established Technology Acceptance Model (TAM) scales (Davis, 1989; Venkatesh et al., 2003). The questionnaire was designed to capture key dimensions relevant to the study, including demographic characteristics of the participants, their awareness of artificial intelligence tools, and their perceptions of perceived usefulness (PU) and perceived ease of use (PEOU). In addition, it incorporated open-ended questions that provided respondents with the opportunity to describe, in their own words, the barriers and enablers they encountered when engaging with AI in teaching.

To ensure both validity and reliability, the instrument underwent expert review by three specialists in educational technology, who examined the clarity, content coverage, and alignment of items with the research objectives. A pilot study involving 30 lecturers was subsequently conducted to further refine the instrument. Statistical analysis of the pilot data confirmed strong internal consistency, with Cronbach's alpha coefficients exceeding 0.85 across all constructs, thereby demonstrating high reliability and suitability of the instrument for the main study.

Data collection was both online and paper-based, to reach lecturers across varying digital access levels. Ethical approval was secured, and all participants gave informed consent, reinforcing the study's commitment to respect and confidentiality.

Quantitative data were processed in SPSS (version 28). Descriptive statistics captured trends, while inferential tests (t-tests, ANOVA, regression) explored relationships between discipline, age, and TAM constructs. Qualitative data were analysed thematically using Braun and Clarke's (2006) six-step approach. This helped reveal the stories behind the numbers—for example, how lecturers described infrastructure challenges or their reliance on peer support. By triangulating these methods, the study moves beyond abstract statistics to provide a holistic picture of lecturers' experiences with AI in Nigerian higher education.

Findings and Discussion

Disparities in AI Awareness

The data revealed a clear digital divide across disciplines. A one-way ANOVA confirmed significant differences in AI awareness: lecturers in STEM fields ($M = 4.2$, $SD = 0.6$) reported stronger familiarity with technical tools such as machine learning and neural networks. In contrast, colleagues in the Humanities ($M = 3.5$, $SD = 0.8$) and Social

Sciences ($M = 3.7$, $SD = 0.7$) were more conversant with user-friendly applications such as Grammarly and ChatGPT. This pattern reflects broader global trends (Crompton & Burke, 2023), where STEM staff are more exposed to computational technologies, while Humanities scholars gravitate towards accessible, text-based tools.

Age also played a significant role. A moderate negative correlation ($r = -0.32$, $p < .01$) showed that older lecturers reported lower familiarity with AI, echoing concerns about generational gaps in digital competence. This finding suggests that while younger staff may experiment more readily with AI, senior faculty might require targeted professional development.

A Typology of Lecturer Attitudes

When qualitative responses were combined with cluster analysis, a typology of lecturer attitudes emerged:

Table 1: Typology of Lecturer Attitudes towards AI Adoption

Attitudinal Group	Prevalence	Description
Enthusiastic Adopters	15–20%	Early champions of AI, often younger staff or those in tech-heavy fields. They see AI as transformative and actively experiment with it.
Pragmatic Adopters	40–50%	The largest group. They are open to AI but weigh benefits against challenges. Adoption depends on institutional support, clear evidence of impact, and ethical guidelines.
Cautious Sceptics	25%	They acknowledge AI's potential but worry about ethics, accuracy, and pedagogical fit. Their adoption tends to be incremental and risk-averse.
Active Resisters	5–10%	A small but vocal group that opposes AI use in education, citing risks to academic integrity and the human dimension of teaching.

The predominance of pragmatic adopters is critical: it signals that most lecturers are not resistant to AI, but they need reassurance through infrastructure, training, and ethical safeguards.

Facilitators and Barriers

Regression results showed that Perceived Usefulness ($\beta = 0.48$, $p < .001$) and Facilitating Conditions ($\beta = 0.31$, $p < .001$) were the strongest predictors of whether lecturers intended to use AI. This means that lecturers were most likely to embrace AI if they could clearly see how it supported their teaching goals and if their institutions provided adequate resources.

Qualitative responses added nuance. Lecturers spoke candidly about both enablers and inhibitors, which are summarised below:

Table 2: Factors Influencing AI Adoption

Facilitating Factors	Inhibiting Factors
Alignment with teaching goals (PU)	Unreliable infrastructure (e.g., electricity, internet bandwidth)
Institutional training and resources	Heavy workload and limited time
Peer influence and success stories	Privacy and data security concerns
Reliable technical support	Fear of professional deskilling
Clear ethical policy frameworks	Lack of tailored, ongoing training

Discussion in Relation to Existing Literature and Context

The findings of this study resonate with broader global research on technology adoption while simultaneously underscoring the unique realities of the Nigerian higher education system. Whereas studies conducted in Western contexts have tended to prioritise issues of ethics, pedagogy, and professional identity in relation to artificial intelligence adoption (Selwyn, 2019; Zhang & Aslan, 2021), the responses of Nigerian lecturers placed consistent emphasis on infrastructural deficits, the high cost of implementation, and institutional gaps in training and support. An especially notable outcome is the identification of "pragmatic adopters," a group that constitutes a critical middle ground between uncritical enthusiasm and outright resistance. Their cautious but open orientation suggests that, given the necessary institutional support, they may serve as pivotal agents in driving sustainable and context-sensitive adoption of AI within Nigerian universities.

Implications and Recommendations

The findings from this study carry important implications at three interconnected levels: national policy, institutional leadership, and professional development.

At the policy level, the message is clear: Nigeria cannot afford to leave the integration of artificial intelligence in education to chance. While university lecturers demonstrate a genuine interest in exploring AI tools, their capacity to adopt them is severely constrained by unreliable electricity supply, the high cost of internet services, and uneven levels of institutional support. To address these challenges, a coordinated national strategy is urgently required. Such a strategy should prioritise investment in infrastructure by expanding broadband access and ensuring a stable electricity supply across university campuses. It should also include the establishment of a National AI-in-Education Ethics Framework that provides clear policy guidance on issues such as data privacy, academic integrity, and responsible use. In addition, sustainable funding models must be mobilised, with agencies such as TETFund supporting the development of campus-level AI innovation hubs. These measures would not only reduce inequalities across institutions but also create an enabling environment in which lecturers' willingness to adopt AI could be translated into meaningful and effective educational practice.

At the institutional level, universities themselves must move beyond the practice of hosting sporadic training workshops and instead develop comprehensive integration roadmaps for AI adoption. This would involve establishing dedicated AI support hubs where academic staff can receive hands-on guidance, as well as fostering communities of practice that enable lecturers to share peer-to-peer learning, exchange ideas, and highlight successful applications. Institutional leadership should also introduce incentive mechanisms, such as grants or teaching awards, to encourage lecturers who creatively and effectively embed AI into student-centred teaching. Without such leadership, efforts are likely to remain fragmented, and many lecturers—particularly those identified as pragmatic adopters—will remain willing but unable to adopt AI in practice.

Equally critical is the professional development of lecturers. Participants in this study repeatedly emphasised the need for training that is not only practical but also continuous and context specific. Short workshops focusing narrowly on tool usage are insufficient to meet the scale of the challenge. Instead, professional development should be embedded in a long-term framework that directly connects AI tools to curriculum objectives and teaching methodologies. Approaches such as micro-credentialing would allow lecturers to build competence incrementally and gain recognition for their skills, while the creation of sandbox environments would enable them to experiment with AI tools in low-risk settings, free from the pressure of live classroom delivery. Importantly, such training should also engage with ethical concerns, including algorithmic bias, plagiarism, and data privacy, thereby ensuring that lecturers approach AI not as a threat to their professional identity but as a pedagogical partner.

Synthesis and Way Forward

The predominance of pragmatic adopters identified in this study underscores a critical window of opportunity for advancing the adoption of artificial intelligence in Nigerian universities. The findings suggest that meaningful and sustainable integration is possible if national policymakers invest in robust infrastructure, if institutions cultivate supportive ecosystems, and if lecturers are provided with continuous and context-sensitive professional development.

The future trajectory of AI in Nigerian higher education is unlikely to be defined solely by sophisticated, high-bandwidth technologies. Instead, it will rest on the adoption of appropriate, low-bandwidth innovations that align with the realities of the local context. These innovations, when combined with strong ethical governance frameworks and opportunities for lecturer-led experimentation, hold the potential to make AI not just accessible but transformative for teaching and learning.

This study therefore advocates an incremental, human-centred strategy for AI adoption in higher education. Such an approach places equal emphasis on technological capacity and on the people and systems that animate educational practice. By valuing infrastructure, policy, and pedagogy in tandem, Nigeria can chart a sustainable pathway that positions AI as a supportive partner in education rather than a disruptive imposition.

Conclusion

This study set out to explore how university lecturers in South-West Nigeria perceive and engage with Artificial Intelligence (AI) tools in their teaching. What emerged is a story not only about technology but about people, institutions, and systems.

The findings show that awareness of AI is growing yet unevenly distributed. STEM lecturers tend to be more comfortable with technical concepts, while colleagues in the humanities and social sciences often engage with everyday applications such as Grammarly or ChatGPT. Age also plays a role, with younger faculty generally more confident than their older counterparts. These disparities highlight that AI adoption is not just about access to tools, but also about the *contexts and capacities* that shape who can use them effectively. Crucially, most lecturers fall into the category of pragmatic adopters: open to experimenting with AI but hesitant without institutional support, reliable infrastructure, and clear ethical guidance. This reflects a readiness that is both promising and fragile. Left unsupported, it risks slipping into frustration or superficial use; but with the right conditions, it can be harnessed into sustainable innovation. The study makes it clear that the future of AI in Nigerian higher education will not be driven by the most advanced or expensive tools, but by those that are appropriate, sustainable, and ethically grounded. Integration will succeed only if it is paired with investments in digital infrastructure, professional development tailored to lecturers' realities, and leadership that values experimentation and collaboration.

In essence, the path forward lies in recognising that AI adoption is as much a human process as it is a technological one. By focusing on people - their needs, skills, and values, universities can transform AI from a distant innovation into a practical ally in the classroom. The challenge, then, is not whether AI can enhance teaching in Nigeria, but whether stakeholders are willing to create the conditions that allow lecturers to move from curiosity to confident, meaningful use. This study provides a roadmap for that transformation, showing that with thoughtful planning, coordinated support, and a commitment to ethics, AI can become a powerful tool for teaching and learning in South-West Nigeria and beyond.

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