



Leveraging Emerging Technologies for Quality Improvement in Nigerian Tertiary Education

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Abstract

This study examined the influence of emerging technologies on quality improvement in Nigerian tertiary education. A cross-sectional correlational survey design was adopted involving 284 academic staff selected through multistage sampling from the University of Uyo and Akwa Ibom State College of Education, Afaha Nsit. Data were collected using the researcher-developed Emerging Technologies and Quality Improvement Questionnaire (ETQIQ) (Cronbach's $\alpha = 0.89$). Mean and standard deviation answered the research questions, while multiple linear regression tested the hypotheses at the 0.05 significance level. Findings revealed a high extent of utilization of emerging technologies (Grand Mean = 3.01), with cloud computing and artificial intelligence recording the highest levels of use. Emerging technologies also exerted a high influence on quality improvement (Grand Mean = 3.36), particularly in teaching effectiveness, student engagement, research productivity, institutional efficiency, graduate digital competence, and innovation capacity. Regression analysis showed that the six technologies jointly explained 69.2% of the variance in quality improvement ($R^2 = 0.692$, $p < .05$). Artificial intelligence, cloud computing, learning analytics, immersive technologies, and the Internet of Things were significant predictors, whereas blockchain technology was not. Major constraints included inadequate infrastructure, unstable electricity, poor internet connectivity, and insufficient funding. The study recommends sustained investment in digital infrastructure, institutional policies, and staff capacity development to accelerate technology-driven quality improvement in Nigerian tertiary education.

Keywords: Artificial intelligence, Cloud computing, Emerging technologies, Learning analytics, Quality improvement, Tertiary education.

Introduction

The rapid advancement of digital technologies has fundamentally transformed higher education, reshaping how knowledge is created, delivered, and applied. Universities are increasingly expected to produce graduates who possess not only disciplinary expertise but also the digital competencies, critical thinking, creativity, and problem-solving skills required in a knowledge-based economy. Consequently, higher education institutions are transitioning from conventional instructional approaches to technology-enhanced learning environments that

promote collaboration, innovation, flexibility, and evidence-based decision-making. This transformation aligns with Sustainable Development Goal 4 (SDG 4), which advocates inclusive and equitable quality education, and is reinforced by organizations such as UNESCO, the Organisation for Economic Co-operation and Development (OECD), and the World Bank, all of which recognize digital transformation as essential for educational quality and sustainable development.

Emerging technologies, including Artificial Intelligence (AI), Learning Analytics, Cloud Computing, Blockchain Technology, the Internet of Things (IoT), and Immersive Technologies such as Virtual Reality (VR) and Augmented Reality (AR), are central to this transformation. Unlike conventional information and communication technologies, these innovations provide intelligent, adaptive, and data-driven capabilities that support personalized learning, automated assessment, predictive analytics, collaborative research, smart institutional management, and immersive learning experiences. Their adoption has expanded opportunities to improve teaching effectiveness, student engagement, research productivity, institutional efficiency, and graduate preparedness for the Fourth Industrial Revolution.

Globally, universities are integrating these technologies into both academic and administrative processes to strengthen educational quality and institutional competitiveness. AI supports intelligent tutoring, automated feedback, and academic decision-making; Learning Analytics enables early identification of at-risk learners; Cloud Computing provides flexible access to digital learning resources; Blockchain enhances the security and authenticity of academic credentials; IoT facilitates smart classrooms and campus management; while Immersive Technologies create authentic experiential learning environments. Together, these technologies are redefining higher education as a digitally connected ecosystem that responds effectively to evolving labour market demands.

In Nigeria, digital transformation has become an important priority for tertiary education. Initiatives by the Federal Ministry of Education, the National Universities Commission (NUC), the National Board for Technical Education (NBTE), the National Commission for Colleges of Education (NCCE), and the Tertiary Education Trust Fund (TETFund) have promoted the adoption of digital infrastructure, learning management systems, online learning platforms, and AI applications. However, their implementation remains uneven because of inadequate infrastructure, unreliable electricity supply, poor internet connectivity, limited funding, weak institutional support, and varying levels of digital competence among academic staff.

Quality improvement in tertiary education extends beyond academic achievement to encompass teaching effectiveness, student engagement, research productivity, institutional efficiency, graduate digital competence, and innovation capacity. Although previous studies have demonstrated the educational value of individual technologies such as AI, VR, Cloud Computing, and Learning Analytics, most have examined these technologies separately or focused primarily on technology adoption and students' academic performance. Consequently, limited empirical evidence exists regarding the combined influence of multiple emerging technologies on broader dimensions of quality improvement within Nigerian tertiary education. This gap limits the evidence available to guide institutional investment, policy development, and strategic digital transformation.

Against this background, this study investigates the influence of Artificial Intelligence, Learning Analytics, Cloud Computing, Blockchain Technology, the Internet of Things, and Immersive Technologies on quality improvement in Nigerian tertiary education. Specifically, it examines how these technologies contribute to teaching effectiveness, student engagement, research productivity, institutional efficiency, graduate digital competence, and innovation capacity, with the aim of providing empirical evidence to support policy formulation, institutional planning, and sustainable quality enhancement in Nigerian higher education.

Conceptual Clarification.

Emerging Technologies

Emerging technologies refer to innovative digital technologies that are evolving rapidly and possess the potential to transform educational practices, institutional processes, and knowledge creation. Unlike conventional information and communication technologies (ICT), which primarily facilitate communication and access to information, emerging technologies incorporate intelligent computing, automation, advanced analytics, immersive environments, and interconnected digital systems to support adaptive, data-driven, and learner-centred educational experiences (Holmes et al., 2022; UNESCO, 2023; OECD, 2023). Their distinguishing characteristics include scalability, interoperability, automation, predictive capability, and the capacity to improve institutional performance through digital innovation.

In higher education, emerging technologies encompass a wide range of digital innovations. This study focuses on six key technologies that are increasingly influencing teaching, learning, research, and institutional management. Artificial Intelligence (AI) supports intelligent tutoring, automated assessment, personalized learning, academic advising, and research assistance (Holmes et al., 2022; Dwivedi et al., 2023). Learning Analytics involves the

collection and analysis of learner data to monitor engagement, predict academic performance, and support evidence-based instructional decisions (Ifenthaler & Yau, 2020). Cloud Computing provides flexible and scalable access to educational resources, collaborative research environments, and virtual learning platforms (Mell & Grance, 2011). Blockchain Technology enhances the security, transparency, and verification of academic credentials and institutional records (Alammery et al., 2019). The Internet of Things (IoT) enables interconnected smart devices that improve classroom management, resource utilization, and campus operations (Atlam et al., 2022). Immersive Technologies, including Virtual Reality (VR), Augmented Reality (AR), and Extended Reality (XR), create interactive learning environments that enhance conceptual understanding and practical skill development (Radianti et al., 2020).

The educational significance of these technologies lies in their ability to improve instructional delivery, facilitate collaborative learning, strengthen research activities, enhance institutional decision-making, and promote innovation. Their integration enables higher education institutions to provide more personalized, flexible, and data-informed learning experiences while improving administrative efficiency and graduate preparedness for digitally driven workplaces. Consequently, emerging technologies are increasingly viewed as strategic enablers of institutional transformation and sustainable educational development.

In this study, emerging technologies are operationalized as the extent to which academic staff utilize Artificial Intelligence, Learning Analytics, Cloud Computing, Blockchain Technology, the Internet of Things, and Immersive Technologies to enhance teaching, learning, research, and institutional management in Nigerian tertiary institutions. These six dimensions constitute the independent variable.

Quality Improvement in Tertiary Education

Quality improvement in tertiary education refers to the continuous enhancement of institutional performance through systematic efforts aimed at improving teaching, learning, research, governance, and innovation. Rather than representing a fixed standard, quality improvement emphasizes ongoing institutional development that enhances educational effectiveness, relevance, accountability, and responsiveness to societal needs (Harvey & Green, 1993; UNESCO, 2024). It reflects an institution's commitment to achieving better educational outcomes through continuous evaluation, innovation, and evidence-based improvement.

Contemporary perspectives recognize quality improvement as a multidimensional concept. It extends beyond traditional indicators such as enrolment and graduation rates to include teaching

effectiveness, student engagement, research productivity, institutional efficiency, graduate digital competence, and innovation capacity (Altbach et al., 2023; OECD, 2023). These dimensions provide a broader assessment of institutional performance and reflect the increasing emphasis on learner-centred education, knowledge creation, and sustainable development within higher education.

Quality improvement is significant because it strengthens institutional competitiveness, enhances graduate employability, supports research excellence, promotes effective governance, and improves stakeholders' confidence in higher education. Institutions that continuously improve these dimensions are better positioned to respond to technological advancement, changing labour market demands, and national development priorities.

In the present study, quality improvement in tertiary education is operationalized as the continuous enhancement of institutional performance measured through six indicators: teaching effectiveness, student engagement, research productivity, institutional efficiency, graduate digital competence, and innovation capacity. These indicators constitute the dependent variable for assessing the influence of emerging technologies in Nigerian tertiary institutions.

Theoretical Framework

Diffusion of Innovations Theory

This study is anchored on the Diffusion of Innovations (DOI) Theory developed by Rogers (2003). The theory explains how innovations are introduced, adopted, and institutionalized within a social system over time. According to Rogers, the adoption of an innovation is influenced by five key attributes: relative advantage, compatibility, complexity, trialability, and observability. Innovations perceived as offering greater benefits, aligning with users' needs and institutional goals, being easy to understand and use, allowing experimentation, and producing visible outcomes are more likely to be adopted successfully.

Within higher education, the Diffusion of Innovations Theory provides a useful framework for understanding how emerging technologies are integrated into teaching, learning, research, and institutional management. Technologies such as Artificial Intelligence, Learning Analytics, Cloud Computing, Blockchain Technology, the Internet of Things, and Immersive Technologies represent educational innovations whose successful adoption depends on institutional readiness, supportive leadership, organizational culture, digital infrastructure, and the willingness of academic staff to incorporate them into their professional practices. As these technologies become widely adopted and institutionalized, they are expected to improve

teaching effectiveness, student engagement, research productivity, institutional efficiency, graduate digital competence, and innovation capacity.

The theory is particularly relevant to this study because it explains the mechanism through which the adoption and integration of emerging technologies can contribute to quality improvement in tertiary education. It provides a theoretical basis for examining the extent to which the utilization of the six dimensions of emerging technologies influences institutional quality outcomes. Consequently, the Diffusion of Innovations Theory underpins the conceptual relationship between the independent variable, Emerging Technologies (Artificial Intelligence, Learning Analytics, Cloud Computing, Blockchain Technology, Internet of Things, and Immersive Technologies), and the dependent variable, Quality Improvement in Tertiary Education.

Empirical Review

Artificial Intelligence and Quality Improvement in Tertiary Education

Recent empirical studies have demonstrated the growing contribution of artificial intelligence (AI) to quality improvement in higher education. Chiu (2024) conducted a systematic review of 120 empirical studies published between 2018 and 2023 to examine the application of AI in higher education. The review found that AI significantly enhanced personalized learning, automated assessment, learner engagement, and instructional effectiveness, although concerns relating to ethics, academic integrity, and data privacy remained. Similarly, Dwivedi et al. (2023) reviewed empirical evidence on generative AI across education and other sectors and reported that AI improved teaching, research productivity, and academic support when implemented responsibly. However, both studies focused exclusively on AI and did not examine its combined influence with other emerging technologies on institutional quality improvement.

Learning Analytics and Student Engagement

Learning analytics has received considerable empirical attention as a tool for improving student learning and institutional decision-making. Viberg et al. (2023) conducted a systematic review of 86 empirical studies on learning analytics in higher education to examine its influence on student learning and institutional decision-making. Using qualitative synthesis, the review found that learning analytics significantly improved student engagement, academic performance, and retention through early identification of at-risk learners and personalized interventions. However, the study focused primarily on learning outcomes and did not examine learning analytics alongside other emerging technologies in improving institutional quality.

Likewise, Ifenthaler and Yau (2020) synthesized empirical evidence on learning analytics and found that data-driven instructional decisions enhanced teaching effectiveness and institutional quality assurance. Nevertheless, these studies concentrated primarily on student learning outcomes and did not investigate learning analytics alongside other emerging technologies within a unified institutional quality framework.

Cloud Computing and Institutional Efficiency

Almazova et al. (2022) investigated the effectiveness of cloud-based educational environments in higher education institutions in Russia. The study aimed to examine how cloud computing technologies support teaching, learning, and institutional operations. A descriptive survey design was adopted involving 312 university lecturers and students selected from three Russian universities. Data were collected using a structured questionnaire and analysed using descriptive statistics and independent-samples t-tests. The findings revealed that cloud computing significantly enhanced collaboration, resource sharing, instructional flexibility, and access to digital learning resources, thereby improving institutional efficiency and supporting blended learning practices. The study recommended increased investment in cloud infrastructure and staff training to maximize educational benefits. However, the research focused primarily on teaching and learning environments and did not examine cloud computing alongside other emerging technologies or its contribution to broader indicators of quality improvement such as research productivity, graduate digital competence, and innovation capacity.

Blockchain Technology and Academic Administration

Alammary et al. (2019) conducted a systematic review of 43 studies drawn from major academic databases to examine the application of blockchain technology in education. The review followed a systematic literature review protocol involving predefined inclusion and exclusion criteria and thematic content analysis. The findings indicated that blockchain technology improved credential verification, academic record management, certification security, institutional transparency, and quality assurance processes. The review further showed that blockchain reduced administrative fraud and enhanced trust in institutional record management. Nevertheless, most of the reviewed studies were conceptual discussions, prototype developments, or pilot implementations, with relatively few large-scale empirical investigations conducted within higher education institutions. Consequently, empirical evidence regarding blockchain's contribution to broader institutional quality improvement, particularly in developing countries such as Nigeria, remains limited.

Internet of Things (IoT) and Smart Learning Environments

Atlam et al. (2022) reviewed empirical studies on the application of the Internet of Things (IoT) in higher education to evaluate its contribution to smart learning environments and institutional management. The review synthesized evidence from more than 50 empirical studies involving smart classrooms, smart laboratories, and smart campus implementations published between 2016 and 2021. Using thematic analysis, the authors found that IoT technologies significantly improved classroom management, attendance monitoring, laboratory automation, energy management, security systems, resource utilization, and institutional efficiency through real-time monitoring and interconnected digital devices. The study concluded that IoT has substantial potential for improving teaching, learning, and campus administration. However, most of the reviewed studies focused on technological implementation and smart campus development rather than examining IoT as an independent predictor of comprehensive quality improvement in tertiary education.

Immersive Technologies (Virtual Reality and Augmented Reality) and Experiential Learning

Radianti et al. (2020) conducted a systematic review of 114 empirical studies published between 2014 and 2019 to investigate the effectiveness of Virtual Reality (VR) applications in higher education. The review employed a systematic search strategy across major scholarly databases and analysed the selected studies using qualitative thematic synthesis. The findings demonstrated that VR significantly improved experiential learning, learner engagement, motivation, conceptual understanding, practical skill acquisition, and knowledge retention, particularly in science, engineering, medicine, and health-related disciplines. The review also reported that immersive learning environments promoted active participation and authentic learning experiences. Although the evidence strongly supported the educational value of VR, the authors noted that many studies focused on learning outcomes, technology acceptance, and usability rather than broader institutional quality indicators such as research productivity, institutional efficiency, graduate digital competence, and innovation capacity. Consequently, further empirical studies examining the contribution of immersive technologies to overall quality improvement in higher education are needed.

Summary table

Author(s)	Technology	Research Design	Key Findings	Gap Identified
Dwivedi et al. (2023)	Artificial Intelligence	Systematic review	AI improved teaching, learning, and research support.	Focused on AI only.
Chiu (2024)	Artificial Intelligence	Literature review	AI enhanced personalized learning and instructional effectiveness.	Limited institutional quality indicators.
Viberg et al. (2023)	Learning Analytics	Empirical review	Improved learner engagement and academic performance.	Did not examine overall quality improvement.
Almazova et al. (2022)	Cloud Computing	Survey	Enhanced collaboration and access to learning resources.	Limited Nigerian evidence.
Alammary et al. (2019)	Blockchain	Review	Improved credential verification and administrative transparency.	Little evidence on institutional quality outcomes.
Atlam et al. (2022)	Internet of Things	of Review	Supported smart classrooms and efficient campus management.	Focused on technological implementation.
Radianti et al. (2020)	VR/AR	Systematic review	Improved experiential learning and practical skills.	Emphasized learning outcomes rather than institutional quality.

Synthesis of Empirical Literature

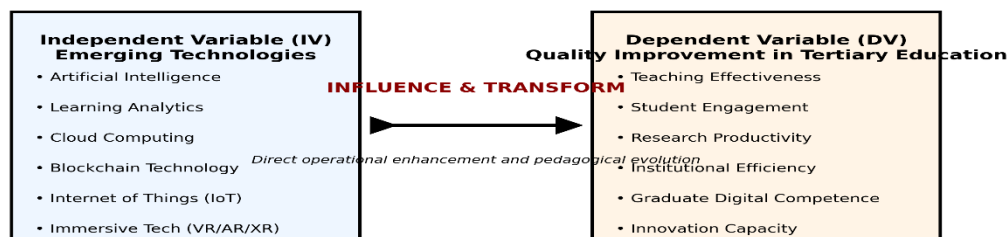
The reviewed studies consistently demonstrate that Artificial Intelligence, Learning Analytics, Cloud Computing, Blockchain Technology, the Internet of Things, and Immersive Technologies positively influence different aspects of higher education, including teaching effectiveness, student engagement, research support, institutional management, and learning outcomes. However, three important gaps are evident. First, most studies investigated each technology independently rather than examining their collective influence. Second, the majority focused on technology adoption, user acceptance, or student academic performance instead of broader indicators of institutional quality improvement. Third, relatively few empirical studies have been conducted within the Nigerian higher education context. Consequently, there is limited evidence regarding the joint and individual contributions of these six dimensions of emerging technologies to quality improvement in Nigerian tertiary institutions. This study addresses these gaps by employing multiple linear regression to examine both the collective and individual influence of Artificial Intelligence, Learning Analytics, Cloud Computing, Blockchain Technology, the Internet of Things, and Immersive Technologies on teaching

effectiveness, student engagement, research productivity, institutional efficiency, graduate digital competence, and innovation capacity.

Conceptual Framework

Conceptual framework showing the hypothesized influence of emerging technologies on quality improvement in tertiary education. Emerging technologies (independent variable) are posited to directly influence and transform key quality indicators (dependent variable) through operational enhancement and pedagogical evolution.

Figure 1. Conceptual Framework of the Study



The framework proposes that the utilization of the six dimensions of emerging technologies exerts both joint and individual influences on quality improvement in tertiary education. Quality improvement is operationalized through six indicators: teaching effectiveness, student engagement, research productivity, institutional efficiency, graduate digital competence, and innovation capacity. This conceptualization aligns with the study's objectives, research questions, hypotheses, and multiple regression model.

Statement of the Problem

Emerging technologies have become critical drivers of quality improvement in higher education, enabling institutions to enhance teaching effectiveness, student engagement, research productivity, institutional efficiency, and graduate digital competence. Technologies such as artificial intelligence, learning analytics, cloud computing, blockchain, immersive technologies, and the Internet of Things are increasingly transforming teaching, learning, research, and institutional management worldwide. Consequently, universities are expected to integrate these technologies to improve educational quality and prepare graduates for the demands of an increasingly digital society (UNESCO, 2024; OECD, 2023).

Despite these developments, the integration of emerging technologies in many Nigerian tertiary institutions remains uneven. Persistent challenges, including inadequate digital infrastructure,

unstable electricity supply, poor internet connectivity, limited funding, insufficient staff capacity, and weak policy implementation, continue to constrain their effective utilization for quality improvement (Nworie, 2021; World Bank, 2024). As a result, many institutions have yet to fully realize the potential of these technologies to improve institutional performance and educational outcomes.

Although previous studies have examined individual technologies such as artificial intelligence, virtual reality, cloud computing, and learning analytics, most have focused on technology adoption or students' academic outcomes. Limited empirical evidence exists on the combined influence of multiple emerging technologies on broader dimensions of quality improvement in Nigerian tertiary education. This study therefore investigates the influence of artificial intelligence, learning analytics, cloud computing, blockchain technology, the Internet of Things, and immersive technologies on quality improvement in Nigerian tertiary education to provide empirical evidence for policy, institutional planning, and sustainable digital transformation.

Purpose of the Study

The purpose of this study was to examine the influence of emerging technologies on quality improvement in Nigerian tertiary education. Specifically, the study sought to:

1. assess the extent to which artificial intelligence, learning analytics, cloud computing, blockchain technology, Internet of Things, and immersive technologies are utilized in Nigerian tertiary institutions;
2. examine the influence of artificial intelligence, learning analytics, cloud computing, blockchain technology, Internet of Things, and immersive technologies on quality improvement in Nigerian tertiary education; and
3. identify the challenges affecting the effective integration of emerging technologies for quality improvement in Nigerian tertiary education.

Research Questions

The following research questions guided the study:

1. To what extent are artificial intelligence, learning analytics, cloud computing, blockchain technology, Internet of Things, and immersive technologies utilized in Nigerian tertiary institutions?
2. To what extent do Artificial Intelligence, Learning Analytics, Cloud Computing, Blockchain Technology, Internet of Things, and Immersive Technologies influence quality improvement in Nigerian tertiary education?

3. What challenges affect the effective integration of emerging technologies for quality improvement in Nigerian tertiary education?

Hypotheses

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

H₀₁: Artificial Intelligence, Learning Analytics, Cloud Computing, Blockchain Technology, Internet of Things, and Immersive Technologies do not jointly have a significant influence on quality improvement in Nigerian tertiary education.

H₀₂: Artificial Intelligence, Learning Analytics, Cloud Computing, Blockchain Technology, Internet of Things, and Immersive Technologies do not significantly predict quality improvement in Nigerian tertiary education when considered individually.

Methodology

This study adopted a cross-sectional correlational survey design to examine the influence of emerging technologies on quality improvement in Nigerian tertiary education. The study was conducted at the University of Uyo (UNIUYO) and Akwa Ibom State College of Education, Afaha Nsit (AKSCOE), selected purposively because of their increasing adoption of digital technologies for teaching, learning, research, and administration. The population comprised 1,248 academic staff from the two institutions, from which a sample of 284 respondents was selected using the Krejcie and Morgan (1970) sample size determination table and a multistage sampling technique involving purposive, proportionate stratified, and simple random sampling. Data were collected using a researcher-developed instrument titled Emerging Technologies and Quality Improvement Questionnaire (ETQIQ), consisting of 64 items measured on a four-point Likert scale ranging from Very High Extent (4) to Very Low Extent (1). The instrument measured six dimensions of emerging technologies, Artificial Intelligence, Learning Analytics, Cloud Computing, Blockchain Technology, Internet of Things, and Immersive Technologies (VR/AR/XR) as the independent variables, while Quality Improvement in Tertiary Education served as the dependent variable. The instrument was validated by three experts in Educational Technology, Measurement and Evaluation, and Educational Management. A pilot test involving 40 academic staff from a tertiary institution outside the study area yielded an overall Cronbach's alpha reliability coefficient of 0.89, indicating satisfactory internal consistency. The questionnaires were administered by the researcher with the assistance of two trained research assistants, and the completed copies were retrieved after administration. Data were analysed using the Statistical Package for the Social Sciences (SPSS) Version 29. Mean and standard deviation were used to answer the research questions, while multiple linear regression was

employed at the 0.05 level of significance, with the six dimensions of emerging technologies entered simultaneously into the regression model to determine their joint and individual contributions to quality improvement in tertiary education.

Results and Analysis

Research Question 1: To what extent are Artificial Intelligence, Learning Analytics, Cloud Computing, Blockchain Technology, Internet of Things, and Immersive Technologies utilized in Nigerian tertiary institutions?

Table 1: Mean and Standard Deviation on the Extent of Utilization of Emerging Technologies in Nigerian Tertiary Institutions (N = 284).

Emerging Technology	Mean	SD	Decision
Artificial Intelligence	3.34	0.71	High Extent
Learning Analytics	3.08	0.76	High Extent
Cloud Computing	3.41	0.68	High Extent
Blockchain Technology	2.62	0.82	High Extent
Internet of Things (IoT)	2.89	0.79	High Extent
Immersive Technologies (VR/AR/XR)	2.73	0.81	High Extent
Grand Mean	3.01	0.76	High Extent

Table 1 shows that emerging technologies are utilized to a high extent in Nigerian tertiary institutions (Grand Mean = 3.01, SD = 0.76). Cloud Computing (M = 3.41, SD = 0.68), Artificial Intelligence (M = 3.34, SD = 0.71), and Learning Analytics (M = 3.08, SD = 0.76) recorded the highest levels of utilization, whereas the Internet of Things (M = 2.89, SD = 0.79), Immersive Technologies (M = 2.73, SD = 0.81), and Blockchain Technology (M = 2.62, SD = 0.82) were comparatively less utilized. Overall, the findings suggest that academic staff have largely embraced established digital technologies, while the adoption of newer technologies remains relatively limited, likely due to infrastructural constraints, implementation costs, and the technical expertise required.

Research Question 2: To what extent do Artificial Intelligence, Learning Analytics, Cloud Computing, Blockchain Technology, Internet of Things, and Immersive Technologies influence quality improvement in Nigerian tertiary education?

Table 2: Mean and Standard Deviation on the Influence of Emerging Technologies on Quality Improvement in Nigerian Tertiary Education (N = 284)

Emerging Technology	Mean (M)	SD	Decision
Artificial Intelligence	3.56	0.63	Very High Extent
Learning Analytics	3.42	0.67	High Extent
Cloud Computing	3.49	0.65	High Extent
Blockchain Technology	3.11	0.72	High Extent
Internet of Things (IoT)	3.23	0.69	High Extent
Immersive Technologies (VR/AR/XR)	3.37	0.66	High Extent
Grand Mean	3.36	0.67	High Extent

Table 2 indicates that emerging technologies influence quality improvement in Nigerian tertiary education to a high extent (Grand Mean = 3.36, SD = 0.67). Artificial Intelligence recorded the highest influence (M = 3.56, SD = 0.63), followed by Cloud Computing (M = 3.49, SD = 0.65), Learning Analytics (M = 3.42, SD = 0.67), Immersive Technologies (M = 3.37, SD = 0.66), the Internet of Things (M = 3.23, SD = 0.69), and Blockchain Technology (M = 3.11, SD = 0.72). Overall, the findings suggest that emerging technologies contribute significantly to teaching effectiveness, student engagement, research productivity, institutional efficiency, graduate digital competence, and innovation capacity, with Artificial Intelligence exerting the greatest influence due to its broad application in teaching, assessment, academic support, and institutional management.

Research Question 3: What challenges affect the effective integration of emerging technologies for quality improvement in Nigerian tertiary education?

Table 3: Mean and Standard Deviation on the Challenges Affecting the Integration of Emerging Technologies for Quality Improvement (N = 284)

Challenges	Mean (M)	SD	Decision
Inadequate digital infrastructure	3.71	0.58	Agree
Poor internet connectivity	3.66	0.61	Agree
Unstable electricity supply	3.74	0.56	Agree
Insufficient funding	3.69	0.60	Agree
Limited digital competence of academic staff	3.32	0.71	Agree
Inadequate technical support	3.38	0.67	Agree
Lack of institutional policies on emerging technologies	3.27	0.73	Agree

Challenges	Mean (M)	SD	Decision
High cost of acquiring and maintaining technologies	3.58	0.64	Agree
Resistance to technological change	3.15	0.76	Agree
Data privacy and cybersecurity concerns	3.29	0.70	Agree
Grand Mean	3.48	0.66	Agree

Table 3 shows that respondents agreed that several factors hinder the effective integration of emerging technologies for quality improvement in Nigerian tertiary education (Grand Mean = 3.48, SD = 0.66). The major challenges were unstable electricity supply (M = 3.74), inadequate digital infrastructure (M = 3.71), insufficient funding (M = 3.69), and poor internet connectivity (M = 3.66). Other identified constraints included the high cost of technology acquisition and maintenance, inadequate technical support, limited digital competence among academic staff, data privacy and cybersecurity concerns, weak institutional policies, and resistance to technological change. Overall, the findings indicate that infrastructural, financial, technical, and organizational barriers continue to limit the effective integration of emerging technologies in Nigerian tertiary institutions.

Hypotheses Testing

H₀₁: Artificial Intelligence, Learning Analytics, Cloud Computing, Blockchain Technology, Internet of Things, and Immersive Technologies do not jointly have a significant influence on quality improvement in Nigerian tertiary education.

Table 4: Multiple Regression Analysis of the Joint Influence of Emerging Technologies on Quality Improvement in Nigerian Tertiary Education (N = 284)

Model	R	R ²	Adjusted R ²	Std. Error	F	Sig.
Regression	0.832	0.692	0.685	0.324	103.74	0.000*

Significant at $p < .05$

The results in Table 4 indicate that the six emerging technologies jointly have a significant influence on quality improvement in Nigerian tertiary education, $F(6, 277) = 103.74$, $p < .05$. The model showed a strong positive relationship ($R = 0.832$), with the technologies collectively explaining 69.2% of the variance in quality improvement ($R^2 = 0.692$). This suggests that the combined adoption of emerging technologies makes a substantial contribution to improving institutional quality. Since $p < .05$, the null hypothesis was rejected.

H₀₂: Artificial Intelligence, Learning Analytics, Cloud Computing, Blockchain Technology, Internet of Things, and Immersive Technologies do not significantly predict quality improvement in Nigerian tertiary education when considered individually.

Table 5: Regression Coefficients Showing the Individual Contributions of Emerging Technologies to Quality Improvement.

Predictor	B	Std. Error	Beta (β)	t	Sig.	Decision
Constant	0.514	0.241	—	2.13	0.034	—
Artificial Intelligence	0.298	0.048	0.332	6.21	0.000*	Significant
Learning Analytics	0.184	0.052	0.192	3.54	0.001*	Significant
Cloud Computing	0.216	0.050	0.231	4.32	0.000*	Significant
Blockchain Technology	0.071	0.046	0.074	1.54	0.125	Not Significant
Internet of Things	0.128	0.047	0.136	2.72	0.007*	Significant
Immersive Technologies (VR/AR/XR)	0.163	0.049	0.171	3.33	0.001*	Significant

Table 5 shows that five of the six emerging technologies significantly predicted quality improvement. Artificial Intelligence was the strongest predictor ($\beta = 0.332$, $p < .001$), followed by Cloud Computing ($\beta = 0.231$, $p < .001$), Learning Analytics ($\beta = 0.192$, $p = .001$), Immersive Technologies ($\beta = 0.171$, $p = .001$), and the Internet of Things ($\beta = 0.136$, $p = .007$). In contrast, Blockchain Technology did not significantly predict quality improvement ($\beta = 0.074$, $p = .125$). Overall, the findings indicate that while emerging technologies collectively enhance quality improvement, Artificial Intelligence and Cloud Computing make the greatest individual contributions.

Discussion of Findings

The findings of Research Question 1 revealed that emerging technologies are utilized to a high extent in Nigerian tertiary institutions, with Cloud Computing, Artificial Intelligence, and Learning Analytics recording the highest levels of utilization. The relatively higher utilization of cloud computing may be attributed to its widespread integration into institutional learning management systems, cloud storage platforms, virtual collaboration tools, and online teaching environments that became increasingly indispensable following the COVID-19 pandemic. Likewise, the strong adoption of Artificial Intelligence reflects the growing availability and accessibility of AI-powered applications such as ChatGPT, intelligent tutoring systems, automated assessment tools, and research support platforms, which have become valuable resources for teaching, research, and academic administration. By contrast, Blockchain Technology, the Internet of Things, and Immersive Technologies recorded comparatively lower

levels of utilization, probably because they require substantial infrastructure, specialized technical expertise, and higher implementation costs, all of which remain significant challenges for many Nigerian tertiary institutions. These findings are consistent with those of Almazova et al. (2022), Chiu (2024), and Dwivedi et al. (2023), who reported increasing adoption of cloud computing and artificial intelligence in higher education, while Alammery et al. (2019), Atlam et al. (2022), and Radianti et al. (2020) similarly observed that blockchain, IoT, and immersive technologies are still emerging in many educational settings.

The findings of Research Question 2 showed that emerging technologies influence quality improvement in Nigerian tertiary education to a high extent, with Artificial Intelligence exerting the greatest influence. This finding may be explained by the versatility of AI across multiple institutional functions. Unlike many other technologies that support specific educational processes, AI simultaneously enhances instructional delivery, personalized learning, automated assessment, academic advising, research productivity, and administrative decision-making. Its broad applicability enables institutions to improve several dimensions of quality concurrently, including teaching effectiveness, student engagement, institutional efficiency, and graduate digital competence. Furthermore, the increasing accessibility of generative AI tools has accelerated their adoption among academic staff, making AI one of the most transformative technologies currently available in higher education. This finding agrees with Chiu (2024), Viberg et al. (2023), Radianti et al. (2020), and Atlam et al. (2022), who reported that emerging technologies significantly enhance instructional delivery, learner engagement, and institutional performance.

The findings of Research Question 3 identified unstable electricity supply, inadequate digital infrastructure, insufficient funding, and poor internet connectivity as the major barriers to the effective integration of emerging technologies. These challenges indicate that successful digital transformation depends not only on the availability of technological innovations but also on the institutional capacity to support their implementation. Frequent power outages, limited internet access, inadequate technical support, and financial constraints reduce opportunities for academic staff to integrate advanced technologies into teaching, research, and administrative practices. Consequently, even institutions that recognize the educational benefits of emerging technologies may struggle to realize their full potential without sustained investment in digital infrastructure and supportive institutional policies. These findings corroborate those of Nworie (2021) and the World Bank (2024), who identified infrastructural deficiencies, inadequate

funding, and weak institutional support as persistent barriers to technology integration in higher education.

The findings relating to Hypothesis 1 revealed that the six dimensions of emerging technologies jointly exert a significant influence on quality improvement in Nigerian tertiary education. The high coefficient of determination ($R^2 = 0.692$) suggests that quality improvement is better explained when emerging technologies are implemented as complementary components of an integrated digital ecosystem rather than as isolated innovations. This highlights the importance of coordinated institutional digital transformation strategies in which Artificial Intelligence, Cloud Computing, Learning Analytics, IoT, Blockchain Technology, and Immersive Technologies reinforce one another to improve teaching, research, governance, and innovation. The finding lends empirical support to Rogers' (2003) Diffusion of Innovations Theory, which posits that the successful diffusion and institutionalization of innovations enhance organizational effectiveness and performance.

The findings for Hypothesis 2 showed that Artificial Intelligence, Cloud Computing, Learning Analytics, Immersive Technologies, and the Internet of Things significantly predicted quality improvement, whereas Blockchain Technology did not make a significant unique contribution after controlling for the other technologies. The strong predictive power of Artificial Intelligence reflects its broad applicability across teaching, assessment, research, and institutional management, making it the most influential technology in the regression model. Cloud Computing also emerged as a significant predictor because it provides the digital infrastructure that supports online learning, resource sharing, collaborative research, and institutional data management. In contrast, the non-significant contribution of Blockchain Technology may be attributed to its relatively limited adoption in Nigerian tertiary institutions, where its applications remain largely confined to credential verification and record management. Since blockchain has not yet been widely integrated into mainstream teaching, learning, or research activities, its independent contribution to overall quality improvement remains limited. This finding is consistent with Alammery et al. (2019), who observed that blockchain implementation in higher education is still at an emerging stage and has not achieved widespread institutional adoption.

Conclusion

This study established that emerging technologies are increasingly utilized in Nigerian tertiary institutions, with cloud computing, artificial intelligence, and learning analytics recording the highest levels of utilization. The findings further revealed that emerging technologies exert a

high influence on quality improvement by enhancing teaching effectiveness, student engagement, research productivity, institutional efficiency, graduate digital competence, and innovation capacity. However, the effective integration of these technologies continues to be constrained by inadequate digital infrastructure, unstable electricity supply, insufficient funding, poor internet connectivity, and limited technical capacity. The regression analysis further demonstrated that the six emerging technologies jointly have a significant influence on quality improvement, while artificial intelligence, cloud computing, learning analytics, immersive technologies, and the Internet of Things made significant individual contributions. Overall, the study concludes that sustained investment in emerging technologies is essential for achieving continuous quality improvement and advancing digital transformation in Nigerian tertiary education.

Recommendations

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

1. Tertiary institution administrators and government agencies should increase investment in reliable digital infrastructure, stable electricity supply, and high-speed internet connectivity to support the effective integration of emerging technologies.
2. Institutional management should provide continuous professional development programmes to strengthen academic staff's competence in the pedagogical and administrative use of artificial intelligence, learning analytics, cloud computing, immersive technologies, and other emerging technologies.
3. The Federal Ministry of Education, NUC, NBTE, and NCCE should develop and implement clear institutional policies and strategic frameworks that promote the adoption, governance, ethical use, and sustainability of emerging technologies in tertiary education.
4. Tertiary institutions should adopt an integrated digital transformation strategy that combines multiple emerging technologies rather than relying on individual technologies, thereby maximizing their collective contribution to teaching quality, research productivity, institutional efficiency, graduate digital competence, and innovation.

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