Advanced Digital Classroom and Students' Academic Achievement: A Comparative Evaluation of Select Tertiary Institutions in Nigeria

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Abstract

The integration of digital technologies in education is transforming teaching and learning globally, yet many Nigerian tertiary institutions remain constrained by limited infrastructure and inconsistent policy support. This study examined the influence of advanced digital classrooms on students' academic achievement across six tertiary institutions representing varying levels of digital readiness. Anchored on the Constructivist Learning theory, the study employed a descriptive survey design involving 450 respondents—300 students and 150 lecturers—selected through stratified random sampling. Data were collected using a validated questionnaire ($\alpha = 0.881$) and analysed with descriptive statistics and Chi-square (χ^2) tests at 0.05 significance level. Findings revealed that digital classroom facilities were moderately available, with federal institutions better equipped than state-owned ones. Students exposed to advanced digital classrooms showed higher engagement and academic achievement, confirming the theoretical assumption that interactive learning enhances knowledge construction. The study recommends increased ICT funding, continuous digital pedagogy training for lecturers, integration of digital learning policies, and establishment of institutional support units to sustain digital teaching practices. By providing empirical evidence on the academic value of digital classrooms, the study contributes to improving educational policy, promoting equity, and advancing the quality of tertiary education in Nigeria.

Keywords: advanced digital classroom, academic achievement, digital learning, tertiary institutions, Nigeria, constructivist theory.

Introduction

Education in the twenty-first century continues to evolve rapidly due to technological advancements, and traditional methods of instruction are increasingly insufficient to meet the demands of global competitiveness and innovation. In Nigeria, the conventional "chalk and talk" model of teaching remains dominant across most tertiary institutions. However, this model has proved ineffective in engaging today's digital-native students who are more accustomed to interactive, multimedia-based learning environments. Consequently, there is a pressing need for a transition from traditional classrooms to advanced digital classrooms that can foster academic achievement and equip learners with the competencies required in a technology-driven economy.

An advanced digital classroom extends beyond a physical room equipped with computers or internet connectivity. It represents an integrated learning ecosystem where technology, pedagogy, and content interact to provide a dynamic, learner-centred educational experience. Key components of such classrooms include interactive whiteboards, video-conferencing tools, real-time assessment platforms, virtual and augmented reality learning modules, and robust Learning Management Systems (LMS) such as Moodle, Canvas, and Google Classroom.

Despite the global shift towards digitalised education, Nigeria continues to lag behind in adopting and implementing advanced learning technologies. According to Adeoye, Adanikin, and Adanikin (2021), only a fraction of Nigerian tertiary institutions possesses the infrastructural and human capacity necessary to sustain digital learning environments. The COVID-19 pandemic further exposed these systemic weaknesses, as many institutions were unable to transition effectively to online learning (Abubakar, 2020).

Research evidence shows that digital learning tools enhance student engagement, critical thinking, collaboration, and academic performance (OECD, 2023). The United Nations Educational, Scientific and Cultural Organisation (UNESCO, 2023) emphasises that educational systems must leverage Information and Communication Technologies (ICT) to prepare students for participation in the global knowledge economy. Yet, most Nigerian tertiary institutions still depend heavily on face-to-face instruction with limited technological support.

The persistent Infrastructure deficits and restricted access to digital resources have continued to hinder educational quality and innovation. As the digital revolution transforms global education systems, Nigeria must adapt by modernising its teaching and learning environments. Advanced digital classrooms — equipped with smart boards, reliable broadband, LMS platforms, and virtual simulation tools

— offer innovative opportunities to strengthen learning outcomes and promote academic excellence.

This study therefore examines the state of digital readiness among selected tertiary institutions in Nigeria, investigates the impact of advanced digital classrooms on students' academic achievement, and proposes strategies for sustainable integration. The study provides evidence geared towards the formulation of workable educational policy, institutional development, and enhanced learning outcomes in the Nigerian tertiary education system.

Purpose of the Study
The main purpose of this study is to examine the necessity of developing advanced digital classrooms as a strategy to enhance students' academic achievement and promote educational excellence in Nigerian tertiary institutions.

Specifically, the study seeks to:
i. Examine the current state of classroom infrastructure and the level of digital technology utilisation in Nigerian tertiary institutions.

ii. Determine the extent to which advanced digital classroom facilities influence students' academic achievement.

iii. Propose feasible strategies for effective implementation of advanced digital classrooms in Nigerian tertiary institutions.

Research Questions
In line with the stated objectives, the following research questions were raised to guide the study:
i. What is the current state of classroom infrastructure and digital technology available in Nigerian tertiary institutions?

ii. To what extent do advanced digital classroom facilities influence students' academic achievement?

iii. What strategies can be adopted to ensure the effective implementation of advanced digital classrooms in Nigerian tertiary institutions?

Research Hypotheses
Based on the purpose and research questions, the following null and alternative hypotheses were formulated for testing:

H_0:   There is no significant difference in academic achievement between students who learn in advanced digital classrooms and those who learn in traditional classrooms in selected Nigerian tertiary institutions.

H_1:   There is a significant difference in academic achievement between students who learn in advanced digital classrooms and those who learn in traditional classrooms in selected Nigerian tertiary institutions.

Literature Review

Conceptual Review

An advanced digital classroom refers to an interactive learning environment that integrates modern information and communication technologies (ICTs) to enhance teaching and learning outcomes. It involves the use of digital tools such as computers, interactive whiteboards, smart projectors, simulation software, internet-based learning platforms, and Learning Management Systems (LMS) including Moodle, Google Classroom, and Canvas (OECD, 2023). These tools facilitate collaboration, communication, creativity, and assessment in ways that traditional classrooms cannot.

In contrast, a traditional classroom relies primarily on teacher-centred instruction - characterised by one-way communication, physical presence, chalkboards, and printed materials (Abubakar, 2020). The shift from traditional to digital classrooms represents a move from passive learning to active, learner-centred engagement, where technology serves as both a medium and a facilitator of knowledge construction (Jonassen, 1999).

Academic achievement in this context denotes the measurable outcomes of learning processes, often represented through students' grades, examination results, performance assessments, and cognitive development. It reflects not only content mastery but also the application of skills, creativity, and problem-solving abilities (Aina, 2022).

Digital learning environments support these outcomes by offering flexibility, instant feedback, adaptive learning paths, and access to diverse knowledge sources (UNESCO, 2023). Thus, the concept of an advanced digital classroom encompasses not only the physical technological infrastructure but also pedagogical innovation, digital literacy, and institutional readiness.

Digital Transformation and Pedagogical Innovation in Tertiary Institutions

The integration of technology into tertiary education has transformed how knowledge is created and disseminated. Studies across Africa indicate that digital classrooms enhance student motivation, engagement, and retention (Adeoye, Adanikin & Adanikin, 2021). In countries such as South Africa and Kenya, digital

tools have been successfully incorporated into blended learning models to bridge access gaps (Ngugi, 2020).

In Nigeria, however, adoption remains uneven. Federal institutions tend to have better digital infrastructure and internet connectivity than state-owned polytechnics and colleges of education (Obidiegwu, 2022). Challenges include inconsistent electricity supply, inadequate broadband access, insufficient ICT-trained staff, and the absence of institutional policy frameworks (Yusuf & Onasanya, 2021).

Nonetheless, there are emerging models of success. For instance, the University of Ilorin, Federal Polytechnic, Ede, and the National Open University of Nigeria (NOUN) have implemented robust e-learning systems that demonstrate the potential of technology-enhanced education. These institutions show that where digital classrooms are properly implemented, students perform better academically and exhibit stronger digital competencies (Adebayo, 2022).

Digital Inequality and Barriers to Implementation
Despite these gains, the digital divide persists across Nigeria's tertiary education landscape. Many state-owned institutions lack reliable internet services and ICT infrastructure, which constrains the adoption of advanced digital classrooms (Okon, 2023). Lecturers often rely on outdated instructional methods due to limited training or resistance to pedagogical change (Ogunleye & Adeniran, 2021).

Socio-economic barriers further exacerbate these challenges. Students from low-income backgrounds often lack personal digital devices or consistent access to data services, limiting their participation in technology-based learning. Institutional funding constraints, coupled with bureaucratic procurement processes, impede the maintenance and upgrading of ICT facilities.

These challenges collectively contribute to poor implementation of digital education policies and undermine efforts to integrate ICT into classroom instruction.

Empirical Insights and Emerging Gaps
Empirical research supports the assertion that digital learning environments improve students' academic performance and learning efficiency (OECD, 2023; UNESCO, 2023). Studies by Adeoye et al. (2021) and Abubakar (2020) revealed that the introduction of digital tools during the COVID-19 pandemic led to improved engagement and continuity of learning among Nigerian students, despite infrastructural limitations.

However, existing literature also highlights several research gaps:

- Most studies have concentrated on universities, leaving polytechnics and colleges of education under-researched.
- Limited comparative studies exist that examine the relationship between digital classroom access and academic achievement across federal and state tertiary institutions.
- Few empirical analyses have been conducted in the South-South geopolitical zone, where variations in digital readiness and institutional support are pronounced.

This study seeks to bridge these gaps by conducting a comparative evaluation of advanced digital classroom use and academic achievement among students in selected tertiary institutions across different ownership types and regions.

Theoretical Framework

This study is grounded in the Constructivist Learning theory (Piaget, 1972; Vygotsky, 1978). The theory posits that learning occurs through active engagement, collaboration, and the internalisation of knowledge rather than passive reception.

According to Piaget, learners build understanding through interaction with their environment and assimilation of new experiences into existing knowledge structures. Vygotsky expands this with his concept of the Zone of Proximal Development (ZPD), which emphasises the importance of social interaction and guided support (scaffolding) in enabling learners to reach higher cognitive levels.

The advanced digital classroom exemplifies these principles: interactive whiteboards, discussion forums, and collaborative digital tools create environments that support discovery learning and peer collaboration. Teachers become facilitators of learning, and students take responsibility for constructing meaning through exploration and feedback.

By situating this research within the constructivist paradigm, the study assumes that students exposed to advanced digital classrooms achieve better academic outcomes than those in traditional learning environments. This theoretical perspective therefore provides the interpretive lens for analysing the study's findings.

Materials and Methods

Research Design

The study adopted a descriptive survey design, which is suitable for obtaining factual information, opinions, and perceptions from a representative sample of respondents. This design was appropriate because it enabled the researcher to examine existing conditions of classroom infrastructure and digital readiness, and

to determine their influence on students' academic achievement in tertiary institutions.

Population of the study
The population comprised all lecturers and students in selected tertiary institutions in Nigeria. These institutions were chosen to represent variations in digital classroom adoption, ownership type, and regional distribution.

A total of six tertiary institutions were purposively selected across different geopolitical and administrative categories:

Table 1
Institutions by ownership

Institution	Ownership	Location (State/Region)	Level ofDigital Classroom Adoption	Justification
Kenule Beeson Saro-Wiwa Polytechnic, Bori	State	Rivers (South-South	Low	Limited digital infrastructure; reliance on traditional instruction
Captain Elechi Amadi Polytechnic, Port Harcourt	State	Rivers (South-South	Low-moderate	Urban institution with partial digital facilities
Federal Polytechnic of Oil and Gas, Bonny	Federal	Rivers (South-South	Moderate	Recent federal investment; developing digital capacity
Federal Polytechnic, Ugep	Federal	Cross River (South-South)	Moderate	New federal institution; expanding digital resources
Federal Polytechnic, Ede	Federal	Osun (South-West)	Fair-strong	Well-established ICT infrastructure and e-learning platforms
Federal Polytechnic, Mubi	Federal	Adamawa (North-East)	Fair-strong	Advanced ICT labs and e-learning adoption through TEFFund projects.

These institutions were selected to ensure representative variation across ownership structures (federal/state), geographic zones (South-South, South-West, and North-East), and levels of digital classroom implementation.

Sample Size Determination

The sample size was determined using Cochran's (1977) formula for large populations:

$$n_0 = \frac{z^2 p(1-p)}{e^2}$$

Where:

$z = 1.96 \ (for\ 95\%\ confidence\ level)$
$p = 0.5 \ (maximum\ variablity)$
$e = 0.05 \ (desired\ precision)$

Substituting these values:

$$n_0 = \frac{(1.96)^2(0.5)(0.5)}{(0.05)^2} = 384.16$$

To account for design effect and possible non-response (estimated at 10%), the sample was adjusted to: 384.16 x 1.1 = 422.6 $\cong$ 450

Thus, 450 respondents were targeted for the study, comprising 300 students and 150 lecturers drawn proportionally from six institutions.

Sampling Procedure

A stratified random sampling technique was adopted to ensure balanced representation of both ownership and respondent categories.

The first stratum was based on institutional ownership (federal or state), and the second on respondent group (lecturers and students). Within each stratum, respondents were randomly selected using departmental lists.

Table 2
Categories of sampled population

Category	Federal institutions (3)	State institutions (2)	Total
Lecturers	90	60	150
Students	210	90	300
Total	**300**	**150**	**450**

This approach ensured that each group had a fair chance of selection while maintaining representativeness across institutional types.

Instrumentation

Data were collected using a structured questionnaire titled Advanced Digital Classroom and Academic Achievement Questionnaire (ADCNAQ), developed by the researcher.

The Instrument comprised three sections:
i. Section A: Demographic information (institution, role, gender, years of experience/study level).

ii. Section B: Availability and utilisation of digital classroom facilities.

iii. Section C: Students' academic performance and perceived learning outcomes.

Items in Sections B and C were structured on a 5-point Likert scale, ranging from Strongly Disagree (1) to Strongly Agree (5).

Validity and Reliability of the Instrument

The questionnaire was subjected to content and face validation by three experts in Educational Measurement and Evaluation, and Educational Technology from tertiary institutions in Nigeria. Their feedback informed revisions to item clarity and relevance.

The reliability of the instrument was established through a pilot study involving 30 respondents from non-sampled institutions. Using the Cronbach's Alpha technique, a coefficient of $\alpha = 0.881$ was obtained, indicating high internal consistency and reliability.

Method of Data Collection

The researcher personally administered the instrument with the assistance of trained research assistants. Both physical distribution and electronic forms (Google Forms) were utilised to reach participants efficiently. Data collection was carried out over four weeks, with a retrieval rate of approximately 95%, yielding 428 valid responses for analysis.

Method of Data Analysis

Data were analysed using the Statistical Package for the Social Sciences (SPSS) Version 25. Descriptive statistics (frequency counts, percentages, means, and standard deviations) were used to summarise respondents' demographic characteristics and perceptions.

To test the study's hypothesis, the Chi-square (χ^2) test of independence was employed at the 0.05 level of significance to determine whether a significant

difference existed in academic achievement between students in advanced digital and traditional classrooms.

The decision rule was as follows:

- If the calculated χ^2 value > critical χ^2 value (df = 2, α = 0.05), reject H_0

- Otherwise, fail to reject H_0.

Ethical Considerations

Ethical approval was obtained from the relevant institutional review boards of the participating institutions. Respondents were informed of the study's purpose, assured of confidentiality, and given the right to withdraw at any time without penalty. Informed consent was obtained prior to participation.

Results and Discussion

Research Question 1:

What is the current state of classroom infrastructure and digital technology available in Nigeria tertiary institutions?

Table 3
Availability of advanced digital classroom facilities (N = 428)

Facilities	Always Available (%)	Occasionally Available (%)	Rarely Available (%)	Not Available (%)	Mean	Decision
Interactive smartboards	25.6	31.2	28.0	15.2	2.67	Moderately available
Learning Management Systems (LMS)	35.8	29.1	23.4	11.7	2.90	Moderately available
Reliable Internet Access	20.5	26.3	33.8	19.4	2.49	Low availability
Digital Projectors	46.7	30.6	15.2	7.5	3.16	Fairly available
Computer laboratories	52.3	26.4	14.1	7.2	3.24	Fairly available
Virtual learning platforms (Zoom, Google Meet)	39.6	28.9	20.4	11.1	2.97	Moderately available

Grand Mean = 2.90 – Interpretation: Advanced digital classroom facilities are moderately across the selected institutions.

Discussion
The findings indicate that while most institutions possess some level of digital infrastructure, the facilities are not uniformly available or effectively utilised. Federal polytechnics, particularly those in the South-West and North-East, showed higher level of readiness compared to their state counterparts. This supports the reports of Adeoye, Adanikin, and Adanikin (2021) and Obidiegwu (2022), which

identified funding and policy gaps as major constraints to ICT implementation in Nigerian tertiary institutions.

Research Question 2:
To what extent do advanced digital classroom facilities influence students' academic achievement?

Table 4
Perceived Influence of advanced digital classrooms on students' academic achievements

ITEMS	SA (%)	A (%)	U (%)	D (%)	SD (%)	MEAN	DECISION
Digital classrooms make learning more engaging	44.6	40.2	8.1	4.7	2.3	4.21	High influence
Access to online resources improves understanding	42	43.2	7.8	4.1	2.9	4.17	High influence
Digital feedback enhances performance	40.7	45.3	7.5	4.2	2.3	4.18	High influence
Digital learning increases motivation to study	38.9	40.6	9.4	6.8	4.3	4.02	High influence
Overall use of digital classroom improves academic results	41.8	39.1	9.6	5.9	3.6	4.1	High influence

Grand Mean = 4.14 → Interpretation: Students and lecturers perceive advanced digital classrooms as highly influential on academic achievement.

Discussion
The results affirm that the introduction of digital tools in teaching enhances learning motivation, engagement, and achievement. This aligns with UNESCO (2023) and OECD (2023) findings that technology-mediated environments foster collaboration and deeper learning. The results also validate the Constructivist Learning Theory, which emphasises active participation and knowledge construction through interactive and social processes (Vygotsky, 1978).

Test of Hypothesis
H_0: There is no significant difference in academic achievement between students in advanced digital classrooms and those in traditional classrooms.

H$_1$: There is a significant difference in academic achievement between students in advanced digital classrooms and those in traditional classrooms.

Table 5
Chi-Square test of difference in academic achievement

Variable	N	χ^2 Calculated	χ^2 Critical	Df	p-value	Decision
Academic Achievement (Digital vs Traditional)	428	12.57	5.99	2	0.002	Reject H$_0$

Interpretation
Since the calculated χ^2 value (12.57) is greater than the critical value (5.99) at 0.05 significance, the null hypothesis is rejected. This indicates a significant difference in academic achievement between students taught in advanced digital classrooms and those in traditional classrooms.

Discussion
The finding implies that the adoption of advanced digital classrooms contributes positively to students' academic outcomes. Students exposed to digital learning tools demonstrate better comprehension, higher participation, and improved grades. These outcomes echo the observations of Adebayo (2022) and Jonassen (1999), who found that interactive digital environments enhance cognitive processing and student engagement.

Research Question 3:
What strategies can be adopted to ensure effective implementation of advanced digital classrooms in Nigerian tertiary institutions?

Table 6
Strategies for effective implementation

Suggested Strategy	SA (%)	A (%)	U (%)	D (%)	SD (%)	Mean	Decision
Increase institutional ICT funding and maintenance.	53.8	32.4	8.3	3.1	2.4	4.32	Strongly agreed
Continuous ICT training for lecturers and staff.	47.1	38.9	7.6	4	2.4	4.25	Strongly agreed
Integrate e-learning policies into curriculum design.	45.9	39.3	8.7	3.9	2.2	4.22	Strongly agreed
Establish dedicated digital support centres.	43.6	42.1	7.4	4.2	2.7	4.2	Strongly agreed
Improve internet connectivity and infrastructure.	51.8	36.2	6.4	3.1	2.5	4.31	Strongly agreed

Grand Mean = 4.26 → Interpretation: Respondents strongly support increased funding, training, and infrastructural improvements.

Discussion:
Respondents emphasised the need for sustainable investment in ICT infrastructure and personnel training. The results are consistent with Yusuf & Onasanya (2021) and Okon (2023), who identified staff development and institutional support as critical success factors for technology integration in higher education.

Summary of Findings
  i.   Advanced digital classrooms are moderately available in Nigerian tertiary institutions, with federal polytechnics showing greater adoption than state institutions.
  ii. There is a significant positive relationship between the use of digital classrooms and students' academic achievement.
  iii. Implementation success depends on adequate funding, staff training, and policy integration.

These findings align with the Constructivist Learning theory, reaffirming that learning is enhanced through interactive, technology-supported engagement.

Conclusion
This study examined the influence of advanced digital classrooms on students' academic achievement across six tertiary institutions in Nigeria. Findings revealed that while digital infrastructure is moderately available, its utilisation and

integration into teaching and learning processes vary significantly across institutions. Federal polytechnics demonstrated higher levels of adoption and readiness compared to state-owned institutions, primarily due to better funding and access to TetFund-supported projects.

The results of the chi-square analysis indicated a significant difference in academic achievement between students exposed to advanced digital classrooms and those in traditional classrooms. Students who engaged in technology-mediated learning reported higher levels of motivation, comprehension, and overall academic performance.

These findings validate the Constructivist Learning theory, confirming that active, technology-supported learning environments enhance knowledge construction and learner engagement. Consequently, the development of digital classrooms should be prioritised as a key strategy for improving educational quality and equity in Nigeria's tertiary education system.

Recommendations

Based on the findings, the following recommendations are proposed:

- **Targeted ICT funding and infrastructure development:** The study found that advanced digital classroom facilities were only moderately available across the six institutions, with state-owned polytechnics lagging behind. To address this, government and funding bodies such as TetFund should prioritise equitable ICT investment across regions. Allocations should focus on broadband connectivity, smart boards, functional computer laboratories, and solar-powered learning facilities to ensure sustainable digital access.

- **Capacity building and digital pedagogy training:** Findings revealed that lecturers' limited digital competence constrained the effective utilisation of existing facilities. Continuous professional development programmes should therefore, be institutionalised to strengthen lecturers' skills in the use of Learning Management Systems (LMS), virtual teaching tools, and blended learning strategies. Such initiatives will enhance student engagement and overall academic achievement.

- **Policy integration and institutional frameworks:** The study showed that inconsistent policy direction hinders sustained digital adoption. The Federal Ministry of Education should develop a comprehensive National Digital Learning Integration Policy mandating the inclusion of digital pedagogy in tertiary curricula. Institutions should complement this with internal ICT

policies covering usage standards, equipment maintenance, and digital evaluation systems.

● **Establishment of digital support and maintenance units:** Respondents identified irregular maintenance as a key barrier to consistent use of digital tools. Each institution should therefore, establish a digital support centre staffed with trained ICT personnel responsible for system maintenance, technical support, and software updates. This will ensure continuous functionality and reduce downtime in teaching and learning.

● **Improved internet connectivity and power supply:** Findings indicated that poor internet access and erratic electricity supply disrupt teaching activities. Collaborations with telecommunication providers and renewable energy firms should be pursued to deliver reliable connectivity and sustainable power solutions, particularly in rural and semi-urban institutions.

● **Monitoring, evaluation, and accountability mechanisms:** The study established that there are no systematic frameworks for assessing digital classroom performance. Institutional quality assurance units should introduce periodic monitoring and evaluation of digital learning outcomes. Data obtained should guide policy decisions, budget priorities, and staff performance reviews to promote transparency and continuous improvement.

Limitations and Future Research

This study was limited to six tertiary institutions, which may not fully represent Nigeria's diverse higher education system. In addition, reliance on self-reported data may have introduced subjective bias. Nevertheless, the study offers credible evidence of the link between digital classrooms and academic achievement. Future research should include a larger sample and adopt mixed or longitudinal approaches to explore how digital learning environments influence teaching practices and student performance over time.

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