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UTILIZATION OF SMART CLASSROOM TECHNOLOGIES AND STUDENTS' ENGAGEMENT IN CHEMISTRY LESSONS IN NORTH CENTRAL NIGERIA COLLEGES OF EDUCATION

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ABSTRACT
This study investigated the utilization of smart classroom technologies and students' engagement in Chemistry lessons in North Central Nigeria Colleges of Education. The study was guided by three research questions and three hypotheses. A descriptive survey research design was adopted. The population consisted of 120 chemistry lecturers and 1,850 NCE Chemistry students from six Colleges of Education in North Central Nigeria, giving a total of 1,970 respondents. A sample of 420 respondents comprising 60 lecturers and 360 students was selected using a multi-stage sampling procedure. Data were collected using a structured questionnaire titled Smart Classroom Technologies and Students' Engagement Questionnaire (SCTSEQ). The instrument was validated by experts in Chemistry Education and Measurement and Evaluation, and its reliability was established using Cronbach's alpha, which yielded an overall coefficient of 0.85. Data were analyzed using mean and standard deviation for the research questions, while independent samples t-test and Pearson Product Moment Correlation were used to test the hypotheses at 0.05 level of significance. Findings revealed that smart classroom technologies were utilized to a high extent in Chemistry lessons, although tools such as virtual laboratories and student-operated digital devices were less frequently used. The study also found that students' engagement in Chemistry lessons was high, with evidence of active participation, motivation, collaboration, and attentiveness during instruction. Furthermore, a significant positive relationship was found between the utilization of smart classroom technologies and students' engagement in Chemistry lessons ($r = 0.684$, $p < 0.05$). The study concludes that effective integration of smart classroom technologies enhances students' engagement in Chemistry education. It recommends improved funding for ICT infrastructure, regular lecturer training, provision of stable electricity and internet facilities, and increased use of interactive digital tools to strengthen teaching and learning outcomes in Colleges of Education.

Keywords: Smart classroom technologies, students' engagement, chemistry education, Colleges of Education, North Central Nigeria.

Introduction

Chemistry education plays a critical role in scientific and technological advancement by equipping learners with conceptual understanding and practical skills applicable to industrial development, healthcare delivery, agricultural productivity, environmental management, and innovation. In Nigeria, Chemistry is a core subject in Colleges of Education designed to prepare competent science teachers and contribute to national development goals (Federal Republic of Nigeria [FRN], 2014). Despite this importance, Chemistry instruction continues to face persistent challenges, including the abstract nature of key concepts, low student participation, limited instructional resources, and declining engagement during classroom activities (Nja et al., 2023). These challenges often result in poor comprehension and reduced interest in the subject. Globally, education systems are increasingly shifting toward technology-enhanced learning environments. Smart classroom technologies refer to digital and interactive instructional tools that support effective teaching and active learning. These include interactive whiteboards, multimedia projectors, simulation tools, virtual laboratories, internet-enabled devices, learning management systems, and artificial intelligence-supported platforms (Olori & Dosunmu, 2024; Ojetunde & Ramnarain, 2023). Such tools promote learner-centred instruction by encouraging collaboration, interaction, and real-time feedback, thereby improving the quality of classroom experiences (Abubakar et al., 2024). This study is anchored on Experiential Learning Theory and Constructivist Learning Theory. Experiential Learning Theory, proposed by Kolb, emphasizes that learning occurs through active experience, reflection, conceptualization, and experimentation. In Chemistry education, this theory supports the use of simulations, virtual laboratories, and interactive demonstrations that allow students to learn by doing rather than passive listening.

Constructivist Learning Theory posits that learners actively construct knowledge through interaction with content, peers, and instructional environments. In smart classrooms, students engage with digital tools and collaborative tasks that enhance meaning-making and deeper understanding of scientific concepts. Both theories support the integration of smart technologies as a means of improving engagement and conceptual mastery in Chemistry instruction. Student engagement is a key outcome of effective instruction and is defined as the extent of students' behavioural, emotional, and cognitive involvement in learning activities (Fredricks et al., 2004). Behavioural engagement reflects participation in academic tasks, emotional engagement involves interest and motivation, while cognitive engagement refers to mental effort and critical thinking. Higher engagement is associated with improved achievement, retention, and positive learning attitudes (Olori & Dosunmu, 2024).

International studies have consistently demonstrated the effectiveness of smart classroom technologies in enhancing science education. For instance, research in technologically advanced learning environments shows that virtual simulations and blended learning approaches significantly improve students' conceptual understanding and engagement in Chemistry (Ajayi et al., 2025). Similarly, studies conducted in Asia and Europe report that digital laboratories, flipped classrooms, and interactive e-learning platforms enhance student motivation, participation, and academic performance in science subjects (George & Osuafor, 2023; Isa & Bukar, 2023). These findings suggest that smart learning environments are increasingly central to modern science instruction worldwide. In Nigeria and other developing contexts, however, the integration of smart classroom technologies remains uneven. Studies indicate that while some institutions have adopted digital tools, many still rely heavily on traditional lecture-based methods that limit student interaction and engagement (Nnoli & Onwudinjo, 2023). In Colleges of Education in North Central Nigeria, challenges such as inadequate ICT infrastructure, unstable electricity supply, insufficient

funding, limited internet access, and low lecturer digital competence continue to hinder effective implementation (Abubakar et al., 2024). Although previous studies have explored ICT integration in science education, there remains limited empirical evidence specifically addressing the utilization of smart classroom technologies and their relationship with student engagement in Chemistry lessons in North Central Nigeria Colleges of Education. Most available research focuses on secondary schools or general academic performance rather than multidimensional engagement (behavioural, emotional, and cognitive) at the tertiary teacher-education level (Nja et al., 2023). Therefore, this study investigates the utilization of smart classroom technologies and students' engagement in Chemistry lessons in North Central Nigeria Colleges of Education, with particular attention to the level of utilization, engagement outcomes, and strategies for improving effective integration in instructional practice.

Statement of the Problem

Despite the growing advancement in educational technologies, the teaching of Chemistry in Colleges of Education in Nigeria is still largely dominated by conventional lecture methods that limit students' active participation and engagement. As a result, many students perceive Chemistry as difficult and abstract, leading to low motivation, weak classroom interaction, and poor learning outcomes. Although smart classroom technologies such as multimedia tools, smart boards, simulations, and virtual laboratories are expected to enhance teaching and students' engagement, their utilization in many Colleges of Education in North Central Nigeria appears inadequate due to challenges such as poor infrastructure, inadequate facilities, limited lecturer competence, and irregular power supply. Previous studies have highlighted the benefits of technology-based instruction in science education; however, limited empirical evidence exists on the utilization of smart classroom technologies and their influence on students' engagement in Chemistry lessons in Colleges of Education in North Central Nigeria. Therefore, this study seeks to examine the utilization of smart classroom technologies and students' engagement in Chemistry lessons in North Central Nigeria Colleges of Education.

Purpose of the Study

The purpose of this study is to examine the utilization of smart classroom technologies and students' engagement in Chemistry lessons in North Central Nigeria Colleges of Education. Specifically, the study seeks to:

1. determine the level of utilization of smart classroom technologies in Chemistry lessons in Colleges of Education in North Central Nigeria;
2. determine the level of students' engagement in Chemistry lessons in Colleges of Education in North Central Nigeria; and
3. examine the relationship between the utilization of smart classroom technologies and students' engagement in Chemistry lessons in North Central Nigeria Colleges of Education

Research Questions

The following research questions guided the study:

1. What is the level of utilization of smart classroom technologies in chemistry lessons in North Central Nigeria Colleges of Education?
2. What is the level of students' engagement in chemistry lessons in North Central Nigeria Colleges of Education?
3. What is the relationship between the utilization of smart classroom technologies and students' engagement in Chemistry lessons in North Central Nigeria Colleges of Education?

Research Hypotheses

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

H01: There is no significant difference in the mean ratings of lecturers and students on the level of utilization of smart classroom technologies in chemistry lessons in North Central Nigeria Colleges of Education.

H02: There is no significant difference in the mean ratings of lecturers and students on the level of students' engagement in chemistry lessons in North Central Nigeria Colleges of Education.

H03: There is no significant relationship between the utilization of smart classroom technologies and students' engagement in Chemistry lessons in North Central Nigeria Colleges of Education.

Methodology

A descriptive survey research design was adopted for the study. The study was conducted in six Colleges of Education offering Chemistry Education programmes in North Central Nigeria. The population comprised 120 chemistry lecturers and 1,850 NCE Chemistry students, giving a total of 1,970 respondents. Population figures were obtained from the Academic Planning Units and Departmental Records of the respective institutions for the 2024/2025 academic session.

A sample of 420 respondents, comprising 60 chemistry lecturers and 360 NCE Chemistry students, was selected using a multi-stage sampling procedure. In the first stage, purposive sampling was employed to select six Colleges of Education based on the availability of Chemistry Education programmes and smart classroom facilities. In the second stage, proportionate stratified sampling was used to allocate the 360 student respondents across the selected institutions according to their student population sizes. In the third stage, simple random sampling was used to select the required number of students from each institution, while the 60 chemistry lecturers were selected through simple random sampling from the participating colleges.

Data were collected using a researcher-developed instrument titled *Smart Classroom Technologies and Students' Engagement Questionnaire* (SCTSEQ). The instrument consisted of 45 items organized into four sections covering demographic information, utilization of smart classroom technologies, students' engagement, and strategies for improving technology utilization. The instrument was subjected to face, content, and construct validation. Face and content validity were established by experts in Chemistry Education and Measurement and Evaluation, while construct validity was established through a pilot study and Exploratory Factor Analysis (EFA). Only items with factor loadings of 0.40 and above were retained.

The reliability of the instrument was determined using Cronbach's Alpha, which yielded coefficients of Utilization of Smart Classroom Technologies 0.82, Students' Engagement 0.85, and Strategies for Improvement 0.88 for the respective scales, with an overall reliability coefficient of 0.85. The questionnaire was administered with the assistance of two trained research assistants. Data were analyzed using mean and standard deviation to answer the research questions, while the independent-samples t-test was used to test the hypotheses at the 0.05 level of significance. A criterion mean of 2.50, representing the midpoint of the four-point Likert scale, was used as the benchmark for decision-making. Ethical approval for the study was obtained from the relevant institutional research ethics committee. Participants were informed of the purpose of the study and provided voluntary consent before participation. Confidentiality and anonymity were maintained throughout the study.

Results

Research Question One

What is the level of utilization of smart classroom technologies in chemistry lessons in North Central Nigeria Colleges of Education?

Table 1.: **Mean Ratings on the Level of Utilization of Smart Classroom Technologies in Chemistry Lessons**

S/N	Items	Mean	SD	Decision
1	Interactive whiteboards are used during chemistry lessons	3.12	0.74	High Extent
2	Multimedia projectors are used for teaching chemistry concepts	3.25	0.69	High Extent
3	Virtual laboratory applications are utilized in chemistry practicals	2.41	0.83	Low Extent
4	Smart classroom technologies improve lesson delivery	3.36	0.71	High Extent
5	Internet facilities are available during chemistry lessons	2.68	0.79	High Extent
6	Digital simulations are used to explain abstract concepts	2.57	0.82	High Extent
7	Students use tablets or computers during chemistry lessons	2.46	0.88	Low Extent
8	Lecturers possess adequate skills in using smart technologies	2.93	0.77	High Extent
9	Smart technologies enhance classroom interaction	3.11	0.73	High Extent
10	Smart classroom technologies are regularly maintained	2.32	0.85	Low Extent
	Grand Mean	**2.82**		

The result in Table 1 revealed that the grand mean score of 2.82 indicates that smart classroom technologies are utilized to a high extent in chemistry lessons in Colleges of Education in North Central Nigeria. However, some aspects such as virtual laboratory applications, students' use of tablets/computers, and maintenance of smart technologies were utilized to a low extent.

Research Question Two

What is the level of students' engagement in chemistry lessons in North Central Nigeria Colleges of Education?

Table 2. Mean Ratings on Students' Engagement in Chemistry Lessons

S/N	Items	Mean	SD	Decision
1	Students actively participate during chemistry lessons	3.28	0.68	High Extent
2	Students ask questions during lessons	3.04	0.71	High Extent
3	Smart technologies improve students' interest in chemistry	3.31	0.73	High Extent
4	Students collaborate during classroom activities	2.96	0.80	High Extent
5	Students pay attention during technology-based lessons	3.20	0.67	High Extent
6	Students complete assigned classroom tasks	2.89	0.74	High Extent
7	Students are motivated during chemistry Practical's	3.14	0.70	High Extent
8	Students interact freely with lecturers	2.76	0.78	High Extent
9	Smart classroom technologies reduce boredom in class	3.18	0.72	High Extent
10	Students demonstrate enthusiasm during lessons	3.07	0.76	High Extent
	Grand Mean	**3.08**		

The findings in Table 2. showed that students' engagement in chemistry lessons was high with a grand mean score of 3.08. The findings suggest that smart classroom technologies positively influence students' participation, motivation, attention, and interaction during chemistry lessons.

Research Question Three

What relationship exists between smart classroom technology utilization and students' engagement in Chemistry lessons in North Central Nigeria Colleges of Education?

Table 3: Pearson Product Moment Correlation Analysis of the Relationship between Smart Classroom Technology Utilization and Students' Engagement

Variables	N	Mean	SD	r-value	p-value	Decision
Smart Classroom Technology Utilization	380	2.82	0.78			
Students' Engagement	380	3.08	0.73	0.68	0.000	Significant Relationship

Significance Level (α) = 0.05

The result presented in Table 1.3 revealed a Pearson Product Moment Correlation coefficient (r) of 0.68 between smart classroom technology utilization and students' engagement in Chemistry lessons in North Central Nigeria Colleges of Education. The correlation coefficient indicates a strong positive relationship between the two variables. This implies that as the utilization of smart classroom technologies increases, students' engagement in Chemistry lessons also tends to increase.

Hypothesis One

H01: There is no significant difference in the mean ratings of lecturers and students on the level of utilization of smart classroom technologies in Chemistry lessons in North Central Nigeria Colleges of Education.

Table 4: t-test Analysis of Lecturers and Students' Mean Ratings on the Utilization of Smart Classroom Technologies

Respondents	N	Mean	SD	Df	t-cal	Sig. (2-tailed)	Decision
Lecturers	60	2.88	0.63				
Students	360	2.79	0.71	418	1.34	0.181	Retain H_0
Total	**420**						

The result presented in Table 4 shows that the calculated t-value of 1.34 with 468 degrees of freedom produced a p-value of 0.181, which is greater than the 0.05 level of significance. Therefore, the null hypothesis was retained. This implies that there is no significant difference between the mean ratings of lecturers and students on the level of utilization of smart classroom technologies in Chemistry lessons in North Central Nigeria Colleges of Education. Both groups shared similar perceptions regarding the extent to which smart classroom technologies are utilized in Chemistry instruction.

Hypothesis Two

H02: There is no significant difference in the mean ratings of lecturers and students on the level of students' engagement in Chemistry lessons in North Central Nigeria Colleges of Education.

Table 5: t-test Analysis of Lecturers and Students' Mean Ratings on Students' Engagement in Chemistry Lessons

Respondents	N	Mean	SD	Df	t-cal	Sig. (2-tailed)	Decision
Lecturers	60	3.12	0.58				
Students	360	3.06	0.66	418	0.95	0.343	Retain H_0
Total	**420**						

Table 5 reveals that the calculated t-value of 0.95 at 468 degrees of freedom yielded a p-value of 0.343, which is greater than the 0.05 level of significance. Consequently, the null hypothesis was retained. The finding indicates that there is no significant difference between the mean ratings of lecturers and students regarding the level of students' engagement in Chemistry lessons in North Central Nigeria Colleges of Education. This suggests that both groups agreed that students demonstrate a high level of engagement during Chemistry lessons.

Hypothesis Three

H03: There is no significant relationship between the utilization of smart classroom technologies and students' engagement in Chemistry lessons in North Central Nigeria Colleges of Education.

Table 6: Pearson Product Moment Correlation Analysis of Smart Classroom Technology Utilization and Students' Engagement

Variables	N	R	Sig. (2-tailed)	Decision
Smart Classroom Technology Utilization	420			
Students' Engagement in Chemistry Lessons	420	0.684	0.000	Reject H_0

Significance Level (α) = 0.05

Table 6 shows the Pearson Product Moment Correlation analysis conducted to determine the relationship between smart classroom technology utilization and students' engagement in Chemistry lessons in Colleges of Education in North Central Nigeria. The analysis yielded a correlation coefficient (r) of 0.684 with a p-value of 0.000, which is less than the 0.05 level of significance. Therefore, the null hypothesis was rejected. The finding indicates that a significant positive relationship exists between the utilization of smart classroom technologies and students' engagement in Chemistry lessons. This implies that increased utilization of smart classroom technologies is associated with higher levels of students' engagement in Chemistry lessons in North Central Nigeria Colleges of Education..

Discussion of Findings

The study found that the utilization of smart classroom technologies in chemistry lessons in North Central Nigeria Colleges of Education. was high. This level of utilization can be explained by the fact that most institutions possess basic digital teaching tools such as projectors, internet access, simulations, and virtual laboratory resources, but these tools are not consistently or fully integrated into daily instructional practice. The high level of utilization is largely influenced by intermittent power supply, limited ICT infrastructure, and inadequate technical support, which discourage sustained use by lecturers. In addition, some lecturers may still lack advanced digital pedagogical skills, leading to selective or occasional use of available technologies rather than full integration into lesson delivery. This pattern aligns with findings from Nigerian studies (Aina & Yusuf, 2024; Nwafor & Okeke, 2025), which similarly reported that availability of ICT tools does

not automatically translate into full classroom integration due to competence and infrastructural challenges. In contrast, countries such as Finland and South Korea record high utilization because of strong ICT policies, continuous teacher training, and reliable infrastructure.

The study further revealed that students' engagement in chemistry lessons was high, indicating that students actively participated in classroom discussions, group work, and practical activities when smart technologies were used. This higher engagement level can be explained by the interactive and visual nature of smart classroom tools, which make abstract chemistry concepts easier to understand and more interesting to learners. When students are exposed to simulations, animations, and virtual experiments, they are more likely to become attentive, motivated, and involved in learning tasks. This finding is consistent with Ugwu and Musa (2023) and Abdullahi and Peter (2024), who reported that technology-enhanced instruction increases students' motivation and participation in science-based subjects. Similarly, studies from the United Kingdom, Singapore, Malaysia, and Turkey show that interactive digital learning environments promote active participation, collaboration, and sustained attention, while lower engagement is typically observed where technology use is inconsistent or teacher-centered methods dominate.

The study also established a significant positive relationship between the utilization of smart classroom technologies and students' engagement in chemistry lessons. This means that as lecturers increase and effectively apply smart technologies in teaching, students become more engaged in learning activities. The significance of this relationship can be explained by the interactive nature of technology-enhanced instruction, which transforms learners from passive recipients into active participants in the learning process. The finding is consistent with Lawal and Danjuma (2025) and Okafor and Bello (2023), who emphasized that ICT infrastructure and teacher competence are strong predictors of effective classroom engagement. International evidence from China and South Korea further supports this result, showing that sustained investment in ICT infrastructure and continuous professional development leads to improved student engagement and academic outcomes, whereas weak ICT systems in parts of Sub-Saharan Africa and South Asia result in reduced effectiveness of technology integration.

The findings are strongly supported by the Technology Acceptance Model (TAM), which explains that perceived usefulness and ease of use influence the adoption and sustained use of technology in teaching. Since lecturers are more likely to use technologies, they find useful and easy to operate, limited skills and infrastructure reduce full utilization. In addition, the Constructivist Learning Theory supports the observed increase in student engagement, as it emphasizes that learners construct knowledge actively through interaction, collaboration, and experience processes that are enhanced through simulations, virtual laboratories, and multimedia instruction. Furthermore, the Human Capital Theory reinforces the findings by explaining that investment in teacher training and ICT infrastructure improves instructional effectiveness and learner outcomes. Together, these theories explain why technology use enhances engagement and why inadequate skills and infrastructure limit full integration. Overall, the findings suggest that while smart classroom technologies are present in North Central Nigeria Colleges of Education, their impact on student engagement is dependent on the level of effective utilization, which is shaped by institutional capacity, teacher competence, and infrastructure availability.

Conclusion

This study concludes that the utilization of smart classroom technologies in chemistry lessons in Colleges of Education in North Central Nigeria is high, as available tools such as projectors, simulations, virtual laboratories, multimedia resources, and internet-based materials are not yet fully integrated into instructional practice. It further concludes that smart classroom

technologies have a positive influence on students' engagement, enhancing participation, motivation, interaction, and understanding of chemistry concepts. Effective utilization is largely dependent on adequate ICT infrastructure, stable electricity, reliable internet access, lecturer training, and continuous technical support. The study provides context-specific empirical evidence that confirms a significant positive relationship between smart classroom technology utilization and students' engagement in chemistry, thereby strengthening the applicability of the Technology Acceptance Model and Constructivist Learning Theory within Nigerian Colleges of Education.

However, the study is limited by its restricted sample of six institutions, the use of self-reported questionnaire data, and a cross-sectional design, which limit generalizability, introduce potential response bias, and restrict causal interpretation over time. Overall, the findings underscore the need for improved investment in ICT infrastructure and teacher capacity development to enhance the integration of smart classroom technologies and improve students' engagement in chemistry education.

Recommendations

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

1. Government and relevant stakeholders should provide adequate funding for the provision and expansion of smart classroom technologies in Colleges of Education.
2. College administrators should organize regular training and retraining programmes for lecturers on the effective use of digital instructional technologies.
3. Institutions should ensure stable electricity supply, reliable internet connectivity, and employ qualified ICT support personnel to maintain and manage smart classroom facilities.
4. Chemistry lecturers should integrate multimedia resources, simulations, and virtual laboratory activities into classroom instruction to enhance students' engagement and learning outcomes.

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