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Evaluating the Role of Smart Classrooms in Enhancing Performance and Retention of NCE Computer Science Students in North-Central Nigeria

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Abstract

This study examined the efficacy of Smart Classrooms in enhancing the academic performance and knowledge retention of Nigeria Certificate in Education (NCE) Computer Science students in Colleges of Education within North-Central Nigeria. Specifically, the study sought to: (i) determine the effect of Smart Classrooms on students' performance in Computer Science, (ii) examine gender differences in retention, and (iii) assess students' attitudes towards learning Computer Science using Smart Classroom technology. Four research questions were raised to guide the investigation. A quasi-experimental research design was adopted, involving a sample of 240 NCE II students (130 females and 110 males) drawn from five intact classes across five Colleges of Education in the region. Two instruments were used for data collection: The Computer Science Performance Test (CSPT) and the Computer Science Attitude Questionnaire (CSAQ). In addition, an instructional package developed by the researchers was utilized for a six-week teaching intervention for both the experimental (Smart Classroom) and control (conventional method) groups. The CSPT was administered twice, at a two-week interval, to measure both performance and retention, while the CSAQ assessed students' attitudes toward Computer Science learning. Data collected were transcribed, coded, and analyzed using mean scores, t-test, and Analysis of Variance (ANOVA). Findings revealed that students taught with Smart Classrooms significantly outperformed their counterparts in the control group in the post-test, indicating the effectiveness of Smart Classrooms in improving academic performance. Furthermore, the Smart Classroom instructional package demonstrated gender inclusivity, as male and female students achieved comparable results. In addition, the experimental group exhibited a more positive attitude towards learning Computer Science compared to students taught through the conventional lecture method. Based on these findings, the study recommends the integration of Smart Classroom technology into teaching and learning processes at all levels of education in Nigeria. It further emphasizes the need for adequate training and professional development of teachers to enable them to effectively deploy Smart Classroom tools in content delivery. This approach has the potential to improve learning outcomes, foster gender equity, and enhance student engagement in Computer Science education and beyond.

Keywords
Efficacy,
Smart classrooms,
Performance,
Retention.

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Introduction

Education is essentially about shaping human behavior and redirecting resources for efficient and effective utilization that would enhance man's reasoning and better living environment. The twenty-first century technology is turning the way knowledge and skills are being transmit between the teacher and the student differently from the traditional approach. Today computers and allied devices are used in classrooms to enhance content delivery, structural presentation and critical analysis of abstract concepts in a real-time (Abdullahi, 2018; Zakari, 2022). One of such technology based tool/technique for making learning real and ease is the use of smart classrooms that are cost effective, flexible, result oriented and time saving. A smart classroom is a digital learning space that's been enhanced and fortified with several resources that remove impediments to constructive knowledge transmission. The introduction and adoption of smart classroom in schools and colleges was to improve the quality of teaching and learning experience in science, technology engineering and mathematics needed for sustainable economic advancement (Ayodele 2021; Okoh, 2024).

Smart teaching refers to the use of modern technology integrated instructional methods that enhance learning experience by using digital tools, online resources, and data analytics to support personalized learning outcomes and poster students' autonomy. It is learning technique that is student-centered, self-paced, real-time engagement and provides prompt feedback (Aliyu, 2022). Educators have identified the benefits of smart classrooms to include among others promote collaborative engagement, flexible, remote and recorded learning, prepare students with essential digital skills and literacy that support teachers by streamlining task and providing data driven feedback. It reduces paper and pen usage while contributing to a go-green initiative in schools and colleges. The aftermath of smart learning devices in educational training and skills development leads to a better learning outcome for students and minimize teacher's domination in class (Gallup, 2022; Hussaini, 2021).

There are varieties of smart classrooms used in teacher training institutions such as the standard, intermediate and student-led smart classes that propel critical thinking and analysis through constructive engagement between learners on one hand and their teachers the other. Thus the internet of things technology mostly used in smart classes fortified learning and evaluation of teaching processes by making it more interactive and immersive using digital tools like smart boards, virtual reality and augmented reality which allows students to visualize complex concepts and remove hitch to effective assimilation and retention of learned topics. (Zakari, 2022, James 2019).

Studies have revealed the adoption and integrated of smart classrooms in tertiary Institutions for content delivery is faced with many challenges and implementation gap that limit its wide acceptability in Colleges. Some of these challenges includes high initial and maintenance cost, technical/operational glitches, dependency on utilities, compatibility issue of hardware and software used, data management and the problem of student distraction during lessons. Thus, Students from disadvantaged backgrounds may lack access to the necessary devices and technology at home, thereby creating a

disparity in learning opportunities among students (Segun, 2018).

Literature Review

There has been a great deal of research into different areas/component of smart classrooms, as anticipated earlier, these works cover a wide range of science disciplines. The education landscape has been changed positively due to technology application in content delivery and evaluation techniques. Today, smart boards, a standard innovation, have made significant impacts in classrooms, thus reducing teachers' burden and enhancing personalized learning experience especially in science and technology based courses (Abdullahi, 2022).

Segun (2018) carried out a study to determine the effectiveness of smart boards, mobile phones and tablets usage on student achievement and attitude towards science. The study employed Expo de facto design using questionnaire as instrument for data collection. A sample size of 50 students was used for the study. The instrument was administered on all the subjects and retrieved after a week. The data collected was analyzed using chi-square and the result shows that digital tools (smart board, mobile phones and tablet) had positively affect students' performance and attitude when compared to the other group of students not exposed these devices.

The finding revealed the indispensability of smart classrooms as morale booster and performance enhancer among science students. Though, the study acknowledged some implementation gap/constraint on the use of the digital tools.

In the recent longitudinal study conducted by Gallup (2022), on the impact of digital tools on teaching at institutes of education. It was discovered that digital tools (smart board, mobile phones, closed circuit television) play a vital role in improving students learning outcomes, thus making learning from home easier and boosting expectations for learning progress. This means that teachers can effortlessly capture their lessons by taking screenshots and instantly save them to be used in future or teachers can save their note for seamless continuation of lesson, to create review materials for student's study at home. The result of the study also revealed that smart classrooms simplify teaching process for teachers to involve remote students using video conferencing technology and that no special cameras are required for capturing of actors.

Statement of the Problem

The inability of students to access quality education owing to corruption, policy summer-sault, lip-service, inflation and foreign exchange related challenges in addition to shortage of technical manpower calls for the integration of technology-based teaching methods like flipped classrooms, video conferencing, spaced learning and smart classrooms among others. These methods guarantee smooth learning by allowing and providing personalized learning experiences especially for science and technology based courses. Studies by Yusuf (2019) and Zakari (2022) have shown key factors that hindered smooth application of smart classrooms in teacher training institutions and that accounted partly for the underachievement of students in science and computer science in particular. Inadequate technical skills, power-

related problems and non-availability of relevant software and hardware are some of the identified constraints to the use of smart-classrooms. Smart classrooms are essentially technology based instruction technique that is user friendly ease to use, cost effective and appropriate for all disciplines. The use of smart classrooms in tertiary institution will address the problems of manpower gap, underfunding, examination malpractice and other learning difficulties in Colleges of Education. Students learn at their own pace and time with minimal intervention from their teachers. This study will proffer solution to the operational hitches and implementation gap of Colleges of Education that are current using smart classrooms as a learning platform for both teachers and students. The architectural concepts of smart classrooms are intended to close the distance between students and teachers, assist instructors in teaching more effectively and enhance conducive learning environment.

Thus, it is important to improve the quality of instruction and learning in teachers training institutions for scientific advancement especially in the face of a depressed economy. Consequently, the study is timely as it is poised to address operational difficulties and implementation gap of smart classrooms within the study area.

Objectives of the Study

The study was conceived on the following objectives which includes to

(i) Compare students' performance arising from the use of smart classroom package and conventional technique in computer science

(ii) Find out retention ability of male and female students taught using smart classrooms

(iii) Find out implementation gap or hitches to effective utilization of smart classrooms in Colleges of Education

(iv) Find out computer science students' attitude to the use of smart classrooms for content delivery.

Research Questions

The following research questions were raised to guide the study

(i) What is the mean difference in performance scores of students' taught computer science in a smart classrooms and their counterpart taught using conventional lecture method?

(ii) Are there difference in the mean score of male and female NCE students taught computer science in smart classrooms?

(iii) What are those implementation constraints to the use of smart classrooms in colleges of education?

(iv) Are there difference in the mean attitude scores of students' taught computer science in Smart Classroom and those taught using the conventional lecture method?

Significance of the Study

The result of this Study provide relevant empirical evidences related to the use of smart classrooms as instructional teaching strategy for science, mathematics and technology, while identifying the likely challenges to their integration and adoption in Colleges of education. The findings of the study will add to existing literature on the

application of technology in education particularly in teaching and assessment of knowledge acquired. Also, the inferences drawn from the study will be helpful to other stakeholders like examination bodies, publishers, parents, counsellor measurement experts among others during strategic planning and curriculum development. Students and teachers can now leverage on digital tool that permit personalized learning and guaranty optimal performance.

Methodology

This study adopted a quasi-experimental design using pretest, post-test experimental and control group. The use of intact classes was based on the fact the quasi experimental design does not necessarily require randomization of subjects. The use of test and questionnaire for data collection was sufficient to provide the needed cause-effect relationship of variables. The target populations of the study were all NCE computer science students in colleges of education within the North-Central Nigeria that are public owned and funded. However, the sample for the study consisted of 240 NCE II students made up of 130 females and 110 males from five (5) colleges of education within the North-Central Nigeria.

The instruments for data collection were Computer Science Performance Test (CSPT) and Computer Students' Attitude Questionnaire (CSAQ) validated by two senior lecturers and a measurement expert for content and construct. The observation and suggestions of the validators were noted in the final draft of the instruments. The subjects were divided into experimental and control group. The experimental group was taught selected computer science topics using the instructional package developed by the researchers, while control group were taught same topics using the conventional lecture method. The two (2) groups were pretested before the administration of the instruments. The CSPT was administered after the 6 weeks instruction on both groups twice to determine students' performance level and retention, while CSAQ was administered to find out students' attitude towards computer science with smart package. The questionnaire was administered on all the subjects and retrived after a week. The opinion responses were coded and performance scores were analyzed using the mean, standard deviation, t-test and analysis of variance. All the research questions were answered and results presented in tables.

Results and Discussion

The result of data collected were analyzed using mean, standard deviation t-test and analysis of variance. The results are presented in tables based on the research questions.

R/Q $_1$: What is the mean difference in performance scores of students' taught computer science in a smart classrooms and their counterpart taught using conventional lecture method?

Table 1.1 t-test analysis of the performance scores of experimental and the control group.

Group	N	$\bar{x}$	SD	Df	t_{cal}	Sign(tailed)	P-value
Experimental	120	63.78	0.344	288	.323	.423	.000
Control	120	49.213	0.676				

The table 1.1 above revealed the mean scores of the experimental and control group as 63.78 and 49.23 respectively. The mean and standard deviation values shows significant difference in performance in favor of the experimental group (student taught computer science in smart classrooms). Also, the calculated t-value of 0.323 is less than 0.405 at 0.05 level of significance. Thus, t = 6.323 at P< 0.05 (P = .000), shows that students taught in smart classrooms outperformed than their counterpart taught using the conventional lecture method.

R/Q 2: Are there difference in the mean score of male and female NCE students taught computer science in smart classrooms?

Table 1.2. t – test analysis of retention ability of the male and female students in the experimental group.

Gender	N	$\bar{x}$	SD	Df	t_{Cal}	Sign(tailed)	P-value
Male	55	62.98	2.324	118	-.293	.649	.0001
Female	65	63.45	2.582				

The results on table 1.2 shows there was no significant difference in the mean and standard deviation scores of the male and female taught using smart classrooms. Thus, t-cal = -.293 at P> .649) indicates that the male and female students had a comparable retention ability in computer science when taught using same digital devices. This results shows that technology application in teaching is gender friendly.

R/Q 3: What are those implementation constraints to the use of smart classrooms in colleges of education?

Table 1.3: mean and standard deviation values on constraints/implementation gap to the use of smart classroom

S/NO	Items	$\bar{x}$	SD	Remark
1.	Smart classroom consists of digital tool that require constant power for it effective usage	3.59	0.378	Agree
2.	Technical competence of the user is an importance success factor to the use of smart classroom in schools.	4.25	1.248	Agree
3.	Smart classrooms are often considered to be expensive because of crucial procurement cost and maintenance/upgrade.	4.03	1.772	Agree
4.	Weather condition play a significant factor to the usage of smart classroom.	3.94	0.925	Agree
5.	Worms, viruses and hackers possess a strong threats to the integration and adoption of smart classrooms	4.50	1.125	Agree

Table 1.3 above revealed the mean and standard deviation on some of the constraint to the use of smart classrooms. Items 1 – 5 had mean values above the threshold of 2.5, which shows the respondents are in agreement that power supply technical knowhow, cost of procurement/maintenance, weather condition and viral infestation are identified challenge to

the implementation of smart classrooms policy in colleges of education in Nigeria.

RQ4: Are there difference in the mean attitude scores of students' taught computer science in Smart Classroom and those taught using the conventional lecture method?

Table 1.4: ANOVA result of computer science student's attitude towards smart classrooms

Source of Variation	Sum of square	Df	Mean square	F	Sign
Between group (combined)	40.248	2	20.124	1.325	.214
Within groups	1777.12	116	15.302		
Total	**1817.368**	**118**			

The result in table 1.4 shows that t_{cal} = 1.525 at P> .214 is less than the alpha at 0.05 level. This reveals that there was significance difference in performance based on the attitude of male and female computer science using smart classrooms. This result indicates that the male and female NCE had positive attitude disposition towards digital technology application in teaching and learning. It is obvious the students interest and attitude are enhanced in a smart class learning environment.

Dissension of Results

The variability in the impact of Smart Classrooms is presented in Table 1.1, which clearly indicates the superior performance of students in the experimental group compared to their counterparts in the control group. This finding aligns with the results of earlier studies conducted by Audu (2020) and Ayodele (2021), who both reported significant improvements in students' performance when technology was integrated into mathematics classrooms. However, it contrasts with Gallup's (2021) findings in a related study, which suggested otherwise within a similar educational context.

The study further demonstrates, as shown in Table 1.2, that the use of Smart Classrooms promotes better performance and retention among both male and female Computer Science students. Interestingly, retention levels were found to be comparable across genders, suggesting that Smart Classrooms provide an equitable learning environment for students in North-Central Nigeria. This outcome supports the findings of Aliyu (2022), who reported minimal gender disparity among science students taught using video conferencing technologies.

In addition, Table 1.3 highlights several impediments and constraints to the full integration and adoption of Smart Classrooms. These challenges include erratic power supply, limited technical competencies among instructors, adverse weather conditions, and the high cost of installation and maintenance of digital learning devices. Such barriers underscore the need for deliberate policy interventions and sustained investment in infrastructure to maximize the potential of Smart Classroom technology.

Finally, the results summarized in Table 1.4 corroborate the findings of Gabriel (2024), who investigated students' perceived usefulness and attitudes toward information and communication technology devices. The present study revealed that both male and female students exhibited a comparable positive attitude toward Smart Classrooms, viewing them as morale boosters and effective learning enhancers. This suggests that the integration of Smart Classrooms can significantly enrich teaching and learning experiences in Colleges of Education within North-

Central Nigeria, irrespective of gender differences.

Conclusion

This study on the efficacy of Smart Classrooms in enhancing students' performance and retention in Computer Science has demonstrated the significant positive impact of digital technologies on knowledge acquisition and dissemination among diverse learners. The findings revealed that students' performance, attitude, and retention are strongly influenced by reinforcement and motivation provided through technology-based learning environments.

Smart Classrooms were found not only to boost students' morale but also to enhance teachers' competencies, instructional effectiveness, and enthusiasm. In addition, their adoption has been shown to reduce lecturers' workload in Colleges of Education, thereby improving efficiency in lesson preparation and delivery. Importantly, the study provided empirical evidence confirming that Smart Classrooms are gender-inclusive, serving as effective tools for learning advancement irrespective of students' gender differences.

Overall, the integration of Smart Classrooms in Computer Science education presents a transformative opportunity for improving the quality of teaching and learning, fostering equitable participation, and preparing students for a technology-driven future.

Recommendations

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

1. Support for Science Teachers: Science teachers, particularly in teacher-training institutions, should be encouraged and supported to integrate technology into teaching and learning. This will strengthen their information and communication technology (ICT) competencies and improve their effectiveness in both content delivery and assessment procedures.
2. Capacity Building: School administrators and education managers should organize regular capacity-building workshops, seminars, and conferences for science teachers. These programs should focus on emerging innovations such as artificial intelligence (AI), virtual reality (VR), and augmented learning to broaden teachers' pedagogical skills.
3. Personalized Learning: Computer Science teachers and educators should design Smart Classroom strategies that promote personalized learning by tailoring instructional content to meet individual learners' needs and addressing specific instructional challenges.
4. Promoting Collaboration and Ethics: Lecturers, students, and administrators should intensify efforts to utilize artificial intelligence tools that support collaborative study, teamwork, and the cultivation of ethical standards within schools.
5. Curriculum Integration: Curriculum planners, policymakers, and examination bodies should incorporate technology-based learning as a core component of teacher education programs. Technology-related courses should be made compulsory, and students should be required to register for and pass them to

ensure a strong foundation in digital literacy.

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