EFFECTS OF UTILIZATION OF INSTRUCTIONAL TECHNOLOGIES ON ACADEMIC PERFORMANCE OF CHEMISTRY STUDENTS IN FEDERAL COLLEGES OF EDUCATION, YOLA ADAMAWA STATE

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Abstract

This study investigated the influence of instructional technologies on the academic performance of Chemistry students in the Federal College of Education, Yola, Adamawa State. Specifically, the study examined the effects of Computer-Based Multimedia Instructional Packages, Digital Interactive Hardware Devices, and Mobile-Assisted Instructional Applications on students' academic performance in Chemistry. A quasi-experimental, non-equivalent pre-test and post-test control group design was adopted. The population comprised 200- and 300-level Chemistry students, while a sample of 148 students selected from four intact classes participated in the study. The Chemistry Academic Performance Test (CAPT), a 50-item multiple-choice instrument with a reliability coefficient of 0.84 determined using the Kuder-Richardson Formula 20 (KR-20), was used for data collection. Data were analyzed using mean and standard deviation to answer the research questions, while Analysis of Covariance (ANCOVA) was employed to test the hypotheses at the 0.05 level of significance. The findings revealed that students taught using Computer-Based Multimedia Instructional Packages obtained a post-test mean score of 76.47 with a mean gain of 35.19, compared to the control group mean score of 58.23 and mean gain of 17.32. Students exposed to Digital Interactive Hardware Devices recorded a post-test mean score of 79.34 and a mean gain of 37.18, while those taught using Mobile-Assisted Instructional Applications achieved the highest post-test mean score of 82.05 and mean gain of 40.20. ANCOVA results showed significant differences between each experimental group and the control group ($p < .05$), leading to the rejection of all three null hypotheses. The study concluded that instructional technologies enhance students' understanding of Chemistry concepts and improve academic achievement more effectively than conventional teaching methods. It was recommended that Chemistry lecturers integrate instructional technologies into classroom teaching and that educational institutions provide adequate technological facilities and support for effective implementation.

Keywords: Instructional Technologies, Academic Performance, Chemistry Students, Multimedia Instruction, Interactive Hardware Devices, Mobile-Assisted Learning.

Introduction

There has been a radical change within the education industry all over the world due to advances in technology and its incorporation into teaching and learning processes. Teacher-centered approaches have increasingly been substituted with learner-centered models that facilitate critical thinking and active learning among learners. In science, which comprises many theoretical and abstract concepts that are not easily imaginable, instructional technologies play an imperative role in facilitating the comprehension process. As such, many educational institutions around the world are adopting instructional technologies as ways of enhancing learners' understanding and performance.

The continent of Africa and especially sub-Saharan regions realize the importance of instructional technologies as key tools for educational advancements in science and mathematics. This notwithstanding, science classes still struggle with the prevalent approach of using conventional lectures to facilitate rote learning. Educational interventions in this regard have focused on developing technology-based instructional tools that are capable of demystifying complex science theories and making them accessible to learners (Alice, 2014).

Chemistry has been found to be occupying a strategic position in Nigerian schools because of its practical application to medicine, agriculture, engineering, and manufacturing, as well as the need for environmental sustainability. Unfortunately, performance of students in chemistry remains unimpressive at both the secondary school level and higher institutions. Poor performance in chemistry subjects has been associated with challenges experienced in comprehending abstract principles like atomic structure, molecular structure, chemical equilibrium, and thermodynamic principles (Mogboh & Okeke, 2021).

Federal Colleges of Education were formed to develop skilled science teachers able to meet current educational needs. The Federal College of Education, Yola is one of the most prominent colleges training future science teachers in Nigeria. It has the mandate of providing exposure to new forms of instructional technologies which would be used in professional teaching practices by these future science teachers.

Some forms of instructional technologies include Computer-Based Multimedia Instructional Packages, Digital Interactive Hardware Devices, and Mobile-Assisted Instructional Applications. Multimedia instruction packages have been proven effective in simplifying complicated concepts using animations, graphics, simulations, and texts for better comprehension (Anyawu et al., 2018). Examples of digital interactive hardware devices include Kyan machines, interactive boards, and projectors (Hussaini et al., 2026). Consequently, mobile-assisted instructional applications enable flexible learning as well as encourage self-directed learning hence leading to better academic performance and motivation among learners (Adie et al., 2022; Oamen, 2025; Audu, 2026).

There is also research evidence that academic achievement of learners may be affected by their preferred mode of learning. Some of the studies that confirm this include Augustine et al. (2021), Ikechukwu (2017), Ariastuti & Wahyudin (2022), and Indriyani & Nurmasitah (2025). Besides, it has been found that educational technology has enabled more inclusive learning as well as improved achievements among diverse students, especially those with special needs (Muhammad et al., 2025). Based on the above discussion, it is imperative that there should be an investigation into the impact of instructional technologies on the academic performance of Chemistry students at the Federal College of Education, Yola.

Statement of the Problem

In spite of the vital significance of Chemistry in science and technology development, there seems to be poor academic achievement on the part of chemistry students in many higher educational institutions in Nigeria, including the Federal College of Education, Yola. Poor academic performance among chemistry students is partly caused by inability to understand concepts, hence, lack of interest in the subject. Such challenges have adverse effects on the process of science teacher preparation, where chemistry is one of the core subjects.

The use of conventional lecture techniques that hardly address the abstractness of many Chemistry concepts is another reason for poor academic achievement among many chemistry students in Nigerian higher educational institutions. Teacher-oriented teaching techniques encourage rote memorization, hence, poor retention, poor comprehension, and poor academic performance (Mogboh & Okeke, 2021). Despite evidence of effectiveness of ICTs in improving teaching and learning processes, it is not known how much they have been used in the delivery of Chemistry in the Federal College of Education, Yola. Lack of infrastructures, absence of necessary technical support, inadequate training of lecturers, and low level of technological skills among lecturers can be the reasons.

This issue is further buttressed by the facts revealed in academic transcripts, which indicate that only 18.10% of students taking Chemistry NCE II and 43.20% of those taking Chemistry NCE III advanced without carryover subjects in the 2023/2024 academic year (FCEY, 2024). In addition, past research has mainly considered secondary schools as the setting, while instructional technology has been looked at as one variable without due regard to Colleges of Education in Northeastern Nigeria. This study is thus aimed at examining the impact of Computer-Based Multimedia Instructional Packages, Digital Interactive Hardware Devices, and Mobile-Assisted Instructional Applications on Chemistry Students at FCE Yola.

Purpose of the Study

The main aim of the study is to analyze the influence of the use of instructional technologies on the academic achievement of chemistry students in Federal College of Education, Yola, Adamawa State. The specific purposes of this study are to determine:

i. the effect of the use of Computer Based Multimedia Instructional Packages on the academic achievement of chemistry students in Federal College of Education, Yola.
ii. the effect of the use of Digital Interactive Hardware Devices on the academic achievement of chemistry students in Federal College of Education, Yola.
iii. the effect of the use of Mobile Assisted Instructional Applications on the academic achievement of chemistry students in Federal College of Education, Yola.

Research Questions

The following research questions would guide the research work.

i. What is the effect of the use of Computer Based Multimedia Instructional Packages on the academic achievement of chemistry students in Federal College of Education, Yola?
ii. What effect do Digital Interactive Hardware Devices have on the mean academic performance of Chemistry students at Federal College of Education, Yola?
iii. What effect do Mobile-Assisted Instructional Applications have on the mean academic performance of Chemistry students at Federal College of Education, Yola?

Hypotheses

The following hypotheses were stated for testing at a certain significance level (0.05):

i. There is no statistically significant difference between the mean academic performances of Chemistry students who are taught using Computer-Based Multimedia Instructional Packages and those that use the traditional classroom teaching method at Federal College of Education, Yola.
ii. There is no statistically significant difference between the mean academic performances of Chemistry students who use Digital Interactive Hardware Devices and those that use the traditional classroom teaching method at Federal College of Education, Yola.
iii. There is no statistically significant difference between the mean academic performances of Chemistry students who use Mobile-Assisted Instructional Applications and those that use the traditional classroom teaching method at Federal College of Education, Yola.

Literature Review

The two theoretical approaches that guide this study are Richard Mayer's Cognitive Theory of Multimedia Learning (CTML) and Lev Vygotsky's Social Constructivism Theory. According to Mayer's Cognitive Theory, learning is greatly facilitated when information is conveyed to students via both the visual and auditory senses. This ensures that information is processed and retained better through multimedia techniques. The use of multimedia instructional packages in Chemistry education reduces cognitive overload through the use of texts, audio messages, animations, and simulations to help understand abstract concepts. The key point about Vygotsky's Social Constructivism theory is that knowledge acquisition is an active process where the learner constructs his/her own knowledge through interaction and socialization. The application of interactive multimedia and mobile technology in educational settings facilitates the learning process for students through the provision of technological support. These tools serve as scaffolding that helps learners engage in learning processes within their zone of proximal development (ZPD). Instructional technologies have become an indispensable part of current science education and include Computer-Based Multimedia Instructional Packages, Digital Interactive Hardware Devices, and Mobile-Assisted Instructional Applications.

Empirical research has continually supported the effectiveness of instructional technologies on students' academic performance. Anyawu et al. (2018) highlighted the effectiveness of computerized multimedia instructions in improving students' performance irrespective of their academic abilities through sensory learning experiences. Mogboh and Okeke (2021), on the other hand, noted that the use of visual and computerized instructions was critical in enhancing students' conceptualization and performance in Chemistry lessons. With respect to interactive hardware technologies, Hussaini et al. (2026) noted that students exposed to Kyan Machine-assisted instructional methods did much better compared to their counterparts in traditional classes. Muhammad et al. (2025) also identified the role of interactive technological devices in promoting learners' engagement and classroom inclusiveness.

Furthermore, instructional applications in mobile devices have been found to positively affect academic achievements. According to Adie et al. (2022), offline mobile learning platforms offer sustainable learning opportunities in areas experiencing weak internet connections. Oamen (2025) also reported the effectiveness of mobile educational applications in significantly increasing students' interest and academic performance. Audu (2026) identified the potential of mobile-assisted learning environments in improving students' academic achievements and self-directed learning capabilities.

However, despite all of these results, the current literature indicates some significant weaknesses. Firstly, most of the studies have centered on secondary school contexts and have ignored the teacher training institutions like the Federal College of Education. Also, there is little consideration of the role of different elements that make up instructional technology, i.e., multimedia packages, interactive hardware devices,

and mobile-assisted instruction programs. In addition, there are few studies conducted in Northeastern Nigeria, especially at the Federal College of Education, Yola. Therefore, this study attempts to fill these research gaps by examining the separate impact of instructional technology components on Chemistry students' academic success at the college.

Methodology

The current study used the quasi-experimental, non-equivalent pre-test and post-test control group design to determine the effect of technology on the academic achievement of Chemistry students in the Federal College of Education, Yola. This study was carried out among second- and third-year Chemistry students. Four intact Chemistry classes comprising 148 students were selected and allocated into three experimental and one control group. In order to collect data, Chemistry Academic Performance Test (CAPT) was administered to participants in this study. It is a 50-item multiple choice test instrument that was designed and validated by experts in Science Education and Educational Measurement. Reliability of CAPT was established by carrying out a pilot study in which the Kuder-Richardson Formula 20 (KR-20) was used. KR-20 value of 0.84 was recorded. Data were collected within eight weeks using pre-test, treatment using different instructional technology which include computer-based multimedia instruction, digital interactive hardware and mobile learning application and post-test administration. Control group students were taught using traditional lecture method. The analysis of data was done using descriptive statistic such as mean and standard deviation to answer research questions, while hypotheses were tested using ANCOVA. Pre-test score was used as a covariate in testing hypothesis.

RESULTS

Research Question One

What is the influence of the use of Computer-Based Multimedia Instructional Packages on the academic performance mean scores of Chemistry students in Federal College of Education, Yola?

Table 4.1: Mean and Standard Deviation of Pre-test and Post-test Scores of Students Taught Using Computer-Based Multimedia Instructional Packages and Conventional Lecture Method

Group	N	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	Mean Gain
Computer-Based Multimedia Instructional Package	36	41.28	6.84	76.47	7.12	35.19
Conventional Lecture Method	35	40.91	7.01	58.23	8.45	17.32

Those students who were taught using Computer-Based Multimedia Instructional Packages had a post-test mean score that was relatively high compared to that of those taught using the conventional lecture method, 76.47 against 58.23. It further means that the students in the experimental group recorded an average gain score of 35.19 compared to 17.32 for those in the control group.

Research Question Two

In what way is the usage of Digital Interactive Hardware Devices likely to affect the academic performance mean scores of Chemistry students at Federal College of Education, Yola?

Table 4.2: Mean and Standard Deviation of Pre-test and Post-test Scores of Students Taught Using Digital Interactive Hardware Devices and Traditional Lecture Approach

Group	N	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	Mean Gain
Digital Interactive Hardware Devices	38	42.16	6.53	79.34	6.81	37.18
Conventional Lecture Method	35	40.91	7.01	58.23	8.45	17.32

The post-test mean score of the students using Digital Interactive Hardware Devices was 79.34, which is higher than the mean score obtained by the control group, 58.23. The mean gain score of 37.18 also shows how Digital Interactive Hardware Devices have affected students' performance in chemistry.

Research Question Three

What is the influence of the utilization of Mobile-Assisted Instructional Applications on the academic performance mean scores of Chemistry students in Federal College of Education, **Yola?**

Table 4.3: Mean and Standard Deviation of Pre-test and Post-test Scores of Students Taught Using Mobile-Assisted Instructional Applications and Conventional Lecture Method

Group	N	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	Mean Gain
Mobile-Assisted Instructional Applications	39	41.85	6.91	82.05	6.25	40.20
Conventional Lecture Method	35	40.91	7.01	58.23	8.45	17.32

Students who were using the Mobile-Assisted Instructional Applications had a mean score of 82.05 after the post-test, while those in the control group scored a mean of 58.23. This clearly shows that the Mobile-Assisted Instructional Applications had a great impact on the performance of students in chemistry.

Test of Hypotheses

Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 levels of significance where pre-test scores acted as the covariates.

Hypothesis One

H01: There is no significant difference in the mean scores of academic performance of Chemistry students who learned through computer-based multimedia instructional packages and those who learned through the lecture method.

Table 4.4: ANCOVA Summary for Computer-Based Multimedia Instructional Packages and Conventional Lecture Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4562.381	2	2281.191	31.847	.000
Pre-test (Covariate)	412.735	1	412.735	5.761	.019
Group	3981.542	1	3981.542	55.573	.000
Error	4871.893	68	71.646		
Total	328154.000	71			
Corrected Total	9434.274	70			

Decision: Given that the p-value is .000 and is lower than 0.05, the null hypothesis should be rejected.

There exists a significant difference between the mean scores for academic performance among Chemistry students who were subjected to computer-based multimedia instructional packages compared to those under the conventional lecture method of teaching.

Hypothesis Two

H02: There is no significant difference in the academic performance mean scores of Chemistry students exposed to digital interactive hardware devices compared to those taught using the conventional lecture method.

Table 4.5: ANCOVA Summary for Digital Interactive Hardware Devices and Conventional Lecture Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5238.614	2	2619.307	38.625	.000
Pre-test (Covariate)	395.182	1	395.182	5.827	.018
Group	4725.006	1	4725.006	69.673	.000
Error	4744.839	70	67.783		
Total	341295.000	73			
Corrected Total	9983.453	72			

Since the p-value (.000) is less than 0.05, the null hypothesis is rejected.

The mean academic performances between students of Chemistry subjected to Digital Interactive Hardware Devices and those subjected to the conventional lecture approach have a significant difference.

Hypothesis Three

H03: There is no significant difference in the mean academic performances between students of Chemistry utilizing Mobile-Assisted Instructional Applications and those subjected to the conventional lecture approach.

Table 4.6: ANCOVA Summary of Mobile-Assisted Instructional Applications and Conventional Lecture Approach

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6147.821	2	3073.911	46.038	.000
Pre-test (Covariate)	426.573	1	426.573	6.390	.014
Group	5628.491	1	5628.491	84.314	.000
Error	4806.617	72	66.759		
Total	358412.000	75			
Corrected Total	10954.438	74			

Decision: Since the p-value (.000) is less than 0.05, the null hypothesis is rejected.

There exists a considerable disparity in the average academic performance of the Chemistry students using Mobile-Assisted Instructional Application versus the students undergoing lectures using the traditional lecture method.

Discussion of Findings

The results from the study have shown that the adoption of Computer-Based Multimedia Instructional Packages had a positive impact on the academic performance of Chemistry students in Federal College of Education, Yola. Students exposed to the use of multimedia instruction scored higher in post-test scores than the ones under the conventional lecture method. This might be because multimedia instruction involves integration of various methods such as text, graphics, audio, animation and simulation, thus helping the learner develop a deeper understanding of abstract concepts in Chemistry. The finding corroborates the study by Mayer (2021), where he states that multimedia instruction leads to increased comprehension of scientific concepts. Also, the results from this study corroborate the findings from Ahmed and Abimbola (2022). In their study, they found out that computer assisted instructional packages have a significant impact on Chemistry students' achievement levels among students at secondary schools in Nigeria.

It was also found out from the study that the use of Digital Interactive Hardware Devices helped improve the academic performance of students in Chemistry. Those students who were instructed using interactive boards and digital presentations scored better in their performance compared to those in the control group. The finding implies that interactive hardware devices play an important role in enhancing learner involvement and making real-time demonstrations easier, hence encouraging active participation among learners. The findings of the study are consistent with those of Al-Azawei and Lundqvist (2021), which show that interactive classroom technologies positively affected students' academic engagement and academic achievement in science courses. Similar findings were made by Owan, Bassey, and Eze (2023), where students' academic achievement and classroom participation were positively impacted by smart boards and interactive teaching devices.

A third important finding of the research is that Mobile-Assisted Instructional Applications positively affected the academic performance of students. Compared to other types of instructional technology used, students exposed to mobile applications scored higher in the post-test and gained more compared to the pre-test performance. The result above is consistent with the work done by Crompton & Burke (2023), who showed that mobile learning can greatly enhance the students' academic performance, level of motivation, and engagement in science classes. Likewise, Yusuf & Afolabi (2022) found that the use of mobile learning applications increased the students' comprehension of Chemistry concepts and improved their performance in Chemistry examinations.

Also, according to the results of the ANCOVA analysis, there were statistically significant differences between the academic performance of the students from the three experimental groups and the control group taught using the lecture method. Thus, all the null hypotheses in the study were rejected. Based on these results, one can conclude that instructional technologies perform better than the traditional lecture method in helping students learn Chemistry. These findings are consistent with those of Adesoji & Olatunbosun (2021), who found that instructional strategies supported by technology greatly enhanced the students' academic performance in Chemistry. It is also consistent with the conclusions reached by Eze, Chinedu, & Bello (2024) that incorporating technological tools in science classrooms plays an important role in improving learning outcomes and critical thinking among students.

Conclusion

From the results obtained in this study, it is evident that the use of instructional technologies has the potential to greatly enhance the performance of Chemistry students at the Federal College of Education, Yola. Students have gained much better comprehension of Chemistry through the use of Computer-Based Multimedia Instructional Packages, Digital Interactive Hardware Devices, and Mobile-Assisted Instructional Applications when compared with the traditional lecture-based approach.

Recommendations

In view of the results and conclusions drawn from this study, the following recommendations were offered:

1. The Chemistry teachers should use Computer-Based Multimedia Instructional Software in their classes to enhance the learning process and improve performance among students.
2. The educational establishments should invest in Digital Interactive Hardware like smart boards and interactive projectors to ensure an effective teaching process of Chemistry.

3. The Mobile-Assisted Instructional Apps should be used in teaching Chemistry to encourage learners.

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