EFFECT OF COMPUTER-BASED INSTRUCTION ON SENIOR SECONDARY SCHOOL STUDENTS' ACADEMIC PERFORMANCE IN BIOLOGY IN ADAMAWA STATE, NIGERIA

By

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Abstract

This study investigated the effect of Computer-Based Instruction (CBI) on senior secondary school students' academic performance in Biology in Adamawa State, Nigeria, with particular emphasis on gender differences. A quasi-experimental pre-test, post-test, non-equivalent control group design was adopted. The population comprised Senior Secondary II (SS II) Biology students in public secondary schools within Yola Education Zone. A sample of 291 students selected through a multi-stage sampling procedure participated in the study, with 146 students assigned to the Computer-Based Instruction group and 145 students to the lecture method group. Data were collected using the Biology Achievement Test (BAT), which was validated by experts and had a Kuder-Richardson 20 (KR-20) reliability coefficient of 0.88. Mean and standard deviation were used 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 Biology using Computer-Based Instruction achieved significantly higher academic performance (mean gain = 36.59) than those taught using the lecture method (mean gain = 22.66), with a statistically significant difference, $F(1, 290) = 63.41$, $p < .05$. The study also found that gender significantly influenced students' academic performance under Computer-Based Instruction, with male students outperforming female students, $F(1, 143) = 48.54$, $p < .05$. It was concluded that Computer-Based Instruction is more effective than the conventional lecture method in improving students' academic performance in Biology. The study recommended that Biology teachers should integrate Computer-Based Instruction into classroom teaching and that schools should provide adequate ICT facilities while adopting gender-responsive instructional strategies to ensure equitable learning opportunities for all students.

Keywords: Computer-Based Instruction, Biology, academic performance, gender, senior secondary school students, Adamawa State.

Introduction

Education serves as the bedrock for societal advancement, fostering the acquisition of knowledge and skills necessary for personal and national development. It plays a pivotal role in shaping individuals' intellectual capacities, ethical values, and problem-solving abilities, which are crucial for societal progress. Through education, individuals gain the competencies required to navigate various aspects of life, including economic, social, and political spheres. According to UNESCO (2022), quality education promotes social mobility, reduces inequalities, and enhances economic growth by equipping individuals with relevant knowledge and skills that empower them to contribute meaningfully to their communities. Furthermore, education is instrumental in fostering global citizenship, as it instills values such as tolerance, cooperation, and innovation. In contemporary societies, the demand for an educated workforce is growing, as industries increasingly rely on skilled professionals to drive economic growth and technological advancements. Additionally, education plays a key role in addressing societal challenges such as climate change, poverty, and public health crises by equipping individuals with the necessary knowledge and critical thinking skills to develop sustainable solutions.

Science education is fundamental to scientific and technological advancement because it develops students' scientific inquiry, critical thinking, and problem-solving skills while enabling them to apply scientific concepts to real-life situations (Ogunleye, 2019; Okebukola & Jegede, 2020). It also prepares learners for careers in medicine, engineering, information technology, and environmental science, thereby contributing to innovation, economic growth, and sustainable national development (Eze & Nwankwo, 2021). Among the science subjects, Biology occupies a central position due to its relevance in medicine, agriculture, environmental management, disease control, food security, and biodiversity conservation (Nwagbo, 2020). Biology education also promotes health literacy, environmental sustainability, and scientific research, while advances in biotechnology, genetic engineering, and bioinformatics have further expanded its applications (Akinyemi & Usman, 2023). Despite its significance, students' academic performance in Biology in Nigeria has remained persistently poor over the years.

Biology is a vital science subject that underpins careers in medicine, agriculture, pharmacy, and biotechnology, yet students' academic performance in the subject remains consistently poor in Nigeria. Recent studies indicate that Biology achievement remains low despite its popularity, with classroom practices and innovative teaching approaches showing positive effects but failing to eliminate poor performance (Uche, Okoye, & Amobi, 2022; Chukwu, 2024; Ugwuoti, 2024). WAEC statistics further reveal that only 45.3% of candidates obtained credit passes in Biology in 2021, compared to 51.2% in 2020, while Chief Examiners' Reports consistently identified weaknesses in genetics, ecology, and experimental biology (WAEC, 2022; Egbunonu & Ugbaja, 2011; WAEC Chief Examiners' Reports, 2014–2019).

Similarly, in Adamawa State, Biology failure rates remained high between 2014 and 2019, ranging from 65.3% to 78.6% (Adamawa State Ministry of Education, 2021). These persistent poor outcomes have been attributed to inadequate instructional materials, overcrowded classrooms, poorly equipped laboratories, and the continued use of teacher-centred lecture methods that limit students' active participation, critical thinking, and conceptual understanding (Adeosun & Salami, 2021; Ahmed & Abimbola, 2021).

To address these instructional challenges, education researchers have proposed the adoption of more student-centered teaching strategies, such as inquiry-based learning, problem-solving approaches, and Computer-Based Instruction (CBI). Studies have shown that incorporating technology into Biology instruction can enhance students' comprehension, engagement, and overall academic performance (Adeosun & Salami, 2021). By integrating digital tools, interactive simulations, and virtual laboratories, students can develop a better grasp of abstract biological concepts, leading to improved outcomes in national examinations.

Computer-Based Instruction (CBI) refers to the use of computers as interactive tools for delivering educational content, facilitating student engagement, and improving learning outcomes. Research has shown that CBI enhances students' motivation, comprehension, and retention of scientific concepts (Liao, 2019). Unlike the traditional lecture method, CBI provides a multimedia-rich learning environment that includes animations, simulations, and interactive exercises, which make abstract biological concepts more tangible and easier to understand. Studies have also demonstrated that students exposed to CBI perform significantly better in Biology compared to those taught using conventional methods (Senteni, 2020). However, while CBI has proven to be effective, gender differences in students' learning experiences and academic performance must also be considered.

Gender has been identified as a significant factor influencing students' academic performance in Biology. Some studies suggest that male students tend to perform better in science subjects due to societal expectations and gender stereotypes that associate science with masculinity (Udo & Ekanem, 2019). Conversely, other research indicates that female students excel in Biology due to their superior memorization and organizational skills (Okeke & Eze, 2020). Additionally, gender differences in access to and familiarity with technology can influence the effectiveness of CBI in improving learning outcomes. Understanding these gender-based variations is crucial for designing instructional strategies that accommodate the learning needs of both male and female students.

Given the persistent poor performance in Biology and the limitations of the traditional lecture method, there is a need for innovative instructional strategies that enhance students' understanding and engagement. This study is justified as it seeks to investigate the effect of Computer-Based Instruction on students' academic

performance in Biology while considering gender differences. By exploring the effectiveness of CBI, this study aims to provide empirical evidence that will inform policy decisions on adopting technology-driven instructional approaches in Nigerian secondary schools.

Statement of the Problem

Biology is one of the core science subjects taught at the secondary school level in Nigeria and serves as a foundation for careers in medicine, pharmacy, agriculture, biotechnology, and related fields. Because of its perceived relative simplicity compared to other science subjects, it attracts large student enrollment nationally (Ajewole, 2006). Ideally, senior secondary school students should demonstrate mastery of Biology concepts through internal and external assessments, achieve consistently high scores in WAEC and NECO examinations, and retain learned concepts for future application in higher education and science-related careers, thereby contributing to national development.

However, the reality in Nigeria falls short of this ideal. Reports from the West African Examinations Council (WAEC) and the National Examination Council (NECO) consistently highlight low achievement in Biology despite its high enrollment. The WAEC Chief Examiner's Reports (2014–2020) indicate persistent weaknesses in critical areas such as genetics, ecology, and experimental biology. National statistics also reflect fluctuating but generally unsatisfactory results; for instance, the West African Examinations Council reported that only 76.36% of candidates obtained five credits including Mathematics and English in 2022, underscoring inconsistencies in students' academic performance across subjects, including Biology (WAEC, 2022; Punch, 2024). In Adamawa State, the situation is particularly worrisome, with failure rates in Biology between 2014 and 2019 ranging from 65.3% to 78.6%, as documented by the State Ministry of Education (2021).

Several factors contribute to this unsatisfactory performance. The predominant teacher-centered instructional approach emphasizes rote memorization rather than active engagement, making it difficult for students to grasp and retain complex biological concepts (Ahmed & Abimbola, 2021). In addition, shortages of qualified teachers, overcrowded classrooms, insufficient laboratory facilities, and unequal access to digital learning resources further compound the problem (Adeosun & Salami, 2021; Premium Times, 2023). These conditions result not only in poor academic performance but also in low retention of learned materials.

Emerging evidence suggests that innovative instructional approaches such as Computer-Based Instruction (CBI) which employs interactive simulations, animations, and digital learning tools can significantly enhance students' achievement, conceptual retention, and interest in science subjects (Adeoye & Aremu,

2022; Ogunleye, 2020). Nonetheless, most of these studies have been conducted in other parts of Nigeria, and contextual realities in Adamawa State such as infrastructural deficits, varying teacher readiness, and uneven student access to technology raise questions about whether such results can be generalized.

This gap underscores the urgent need for empirical investigation into the effect of Computer-Based Instruction on students' academic performance and retention in Biology within Adamawa State. Furthermore, the study seeks to examine whether gender differences influence students' performance under this instructional strategy. Addressing this problem will provide evidence-based insights into how innovative, technology-driven pedagogy can improve learning outcomes in Biology and help close persistent achievement gaps in science education.

Objectives of the Study

The main purpose of the study is to determine the Effects of Computer-Based Instruction on senior secondary school Biology, students' Academic Performance and Retention in Adamawa State, Nigeria. Specifically, the study seeks;

1. Determine the academic performance of senior secondary school students when taught biology with computer based-instructional and lecture method.
2. Determine the effect of gender on students' academic performance when taught biology with computer based-instruction.

Research Questions

The following research questions will guide the study:

1. What are the differences in the pre-tests and post-test mean performance scores of students taught Biology using computer based-instruction and those taught using lecture method?
2. What are the differences in the pre-tests and post-test mean performance scores of male and female students taught biology using computer based-instruction?

Hypotheses

The following hypotheses are formulated and were tested at 0.05 levels of significance.

Ho_1: There is no significant difference in the mean academic performance scores of students taught biology with computer based-instruction and those taught with lecture method.

Ho_2: There is no significant difference in the mean academic performance of male and female students taught using computer-based instruction.

Literature Review

Computer-Based Instruction (CBI) has emerged as an innovative learner-centred instructional approach that integrates text, graphics, animations, audio, video, and simulations to facilitate meaningful learning. Rooted in Mayer's Cognitive Theory of Multimedia Learning, CBI enhances students' understanding by presenting information through both visual and verbal channels, thereby improving comprehension, academic performance, and retention of scientific concepts (Mayer, 2001; Mayer, 2005). Unlike the conventional lecture method, CBI actively engages learners, promotes critical thinking, and simplifies abstract Biology concepts through interactive multimedia resources.

Several empirical studies have demonstrated the effectiveness of Computer-Based Instruction in Biology education. Yusuf, Mudasiru and Afolabi (2010), Serin (2011), Chaudhari (2013), Gupta and Chirag (2014), and Kannan, Sivapragasam and Senthilkumar (2015) found that students taught using CBI performed significantly better than those taught through the conventional lecture method. Similarly, Lawal and Saka (2024), Yusuf and Abdullahi (2024), and Koech and Chepkoech (2022) reported that Computer-Based Instruction significantly improved students' retention of Biology concepts by enhancing visualization, active participation, and long-term memory. However, Okonkwo and Eze (2023) cautioned that poorly designed multimedia instruction may overload learners' cognitive capacity and reduce learning effectiveness. Regarding gender, findings remain inconclusive. While some studies reported significant gender differences in Biology achievement (Ewumi, 2011; Opara, 2011), others found no significant differences when innovative instructional approaches were employed (Afuwape, 2011; Umar, 2011). These mixed findings underscore the need for further investigation into the effectiveness of Computer-Based Instruction on students' academic performance and retention in Biology within the context of Adamawa State, Nigeria.

Methodology

The study adopted a quasi-experimental research design involving a pre-test, post-test, non-equivalent control group design to determine the effect of Computer-Based Instruction (CBI) on senior secondary school students' academic performance and retention in Biology in Adamawa State, Nigeria. The study was conducted in four public senior secondary schools in Yola Education Zone. The population comprised all Senior Secondary II (SS II) Biology students, while the sample consisted of intact classes selected through a multi-stage sampling procedure. Two schools were assigned to the experimental group and taught using Computer-Based Instruction, while two schools served as the control group and were taught using the conventional lecture method. The instructional treatment covered three Biology topics: Digestive System, Osmosis, and Excretory System, over a period of six weeks.

Data were collected using the Biology Achievement Test (BAT), which served as the pre-test and post-test. The instrument was validated by experts in Biology Education, Educational Technology, and Measurement and Evaluation. The reliability of the BAT was established using the Kuder-Richardson Formula 20 (KR-20), yielding a reliability coefficient of 0.88, indicating that the instrument was highly reliable. Data were analysed 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, with pre-test scores used as covariates to control for initial group differences.

Results and Discussion

Research Question 1

What are the differences in the pre-tests and post-test mean performance scores of students taught biology using computer based-instruction and those taught using lecture method?

Table 1: Mean and Standard Deviation of Pre – Test and Post Test Mean Scores of Students taught Biology using Computer Based Instruction and those taught using Lecture Method

Group		Pre – test		Post – test		Mean difference
	N	M	S. D	M	S. D	
Computer Based Instruction	146	15.45	12.07	52.04	17.38	36.59
Lecture method	145	17.77	13.62	40.43	17.74	22.66

Analysis in Table 1 shows the summary of mean and standard deviation of pre test and post test scores of students taught Biology with computer based instruction and those taught with lecture method. The pre test and post test mean scores of students taught Biology with computer based instruction are 15.45 with S.D = 12.07 and 52.04 with S.D = 17.38 respectively. The students taught Biology using lecture method had pre test and post test mean scores of 17.77 with S. D = 13.62 and 40.43 with S. D = 17.74 respectively. The mean difference (mean gain) between the post test and pre test mean scores of the experimental group is 36.59 which is higher than that of the control group (22.66). This means that students taught using computer based instruction performed better than students taught using lecture method.

Research Question 2

What are the differences in the pre-tests and post-test mean performance scores of male and female students taught biology using computer based-instruction?

Table 2: Mean and Standard Deviation of Pre – Test and Post Test Scores of Male and Female Students taught Biology using Computer Based Instruction and those taught using Lecture Method

Teaching Method			Pre – test		Post – test	
	Gender	N	M	S. D	M	S. D
Computer Based Instruction	M	63	16.70	11.37	62.13	16.88
	F	83	14.49	12.56	44.39	13.47
Lecture method	M	61	22.43	15.11	49.46	19.94
	F	85	14.40	11.30	33.48	12.91

The results presented in Table 2 show the mean and standard deviation scores of male and female students taught biology using Computer-Based Instruction (CBI) and those taught using the Lecture Method, comparing their pre-test and post-test performance.

For students taught with Computer-Based Instruction, there was a substantial improvement from pre-test to post-test scores for both males and females. Male students had a pre-test mean score of 16.70 (SD = 11.37), which increased markedly to 62.13 (SD = 16.88) in the post-test. Similarly, female students' mean score rose from 14.49 (SD = 12.56) in the pre-test to 44.39 (SD = 13.47) in the post-test. This significant increase in mean scores for both genders indicates that computer-based instruction had a strong positive effect on students' performance in biology. However, male students performed better than female students both before and after instruction, with a greater improvement in post-test results.

For students taught using the Lecture Method, a similar upward trend was observed from pre-test to post-test, but the overall improvement was smaller compared to those taught with CBI. Male students' mean score increased from 22.43 (SD = 15.11) in the pre-test to 49.46 (SD = 19.94) in the post-test, while female students' mean score improved from 14.40 (SD = 11.30) to 33.48 (SD = 12.91). Again, male students outperformed female students in both tests, although both genders showed progress after instruction.

Ho_1: There is no significant difference in the mean academic performance scores of students taught biology with computer based-instruction and those taught with lecture method

Table 3: Summary of ANCOVA of Difference in the Mean Academic Performance Scores of Students taught Biology with Computer Based-Instruction and those taught with Lecture Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	45520.871[a]	4	11380.218	60.952	.000	.460
Intercept	144992.229	1	144992.229	776.568	.000	.731
Pretest	14519.255	1	14519.255	77.764	.000	.214
Teaching method	11839.650	1	11839.650	63.412	.000	.181
Gender	14021.044	1	14021.044	75.096	.000	.208
Teaching method gender	*323.094	1	323.094	1.730	.189	.006
Error	53398.799	286	186.709			
Total	721595.000	291				
Corrected Total	98919.670	290				

a. R Squared = .460 (Adjusted R Squared = .453)

b. Computed using alpha = .05

ANCOVA analysis in Table 3 was conducted to test whether significant difference exist between the mean academic achievement scores of students taught Biology using computer based instruction and those taught using lecture method. The result shows that there is significant mean difference in the academic achievement scores of students taught Biology using computer based instruction and those taught using lecture method $F(1, 290) = 63.412$, $p<0.05$) with a moderate effect size as indicated by the partial eta square of 0.181. This means that the null hypothesis is rejected since the p – value is less than 0.05 level of significance.

Ho_2: There is no significant difference in the mean academic performance of male and female students taught using computer-based instruction.

Table 4: Summary of ANCOVA of Difference between the Mean Academic Performance of Male and Female Students taught Using Computer-Based Instruction

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared

Corrected Model	11342.640[a]	2	5671.320	24.981	.000	.259
Intercept	147401.843	1	147401.843	649.265	.000	.820
Pre-test	69.534	1	69.534	.306	.581	.002
Gender	11020.637	1	11020.637	48.543	.000	.253
Error	32465.113	143	227.029			
Total	439216.000	146				
Corrected Total	43807.753	145				

a. R Squared = .259 (Adjusted R Squared = .249)

The result in Table 4 shows that gender had a statistically significant effect on students' academic performance when taught using computer-based instruction, $F(1,143) = 48.543$, $p < .05$. Since the significance value is .000, which is less than the 0.05 alpha level, the null hypothesis is rejected. This means that there is a significant difference in the mean academic performance of male and female students. The partial eta squared value of .253 indicates that gender accounted for about 25.3% of the variance in students' academic performance after controlling for pre-test scores, suggesting a moderately strong effect size. In other words, the use of computer-based instruction did not benefit male and female students equally; one gender achieved higher performance levels than the other.

Findings of the Study

The following are the findings of the study.

1. The finding of the study reveals that students taught Biology using computer-based instruction showed a greater improvement from pre-test to post-test (mean gain = 36.59) compared to those taught with the lecture method (mean gain = 22.66). The result indicates that students taught using computer-based instruction performed significantly better than those under the lecture method in academic performance [$F(1, 290) = 63.41$, $p < 0.05$].

2. The finding of the study reveals that male students taught using computer-based instruction had a higher post-test mean score (62.13) than female students (44.39), with a mean gain difference of 17.74 in favour of males. The ANCOVA result indicates that gender had a significant effect on students' academic performance when taught with computer-based instruction [$F(1, 143) = 48.54$, $p < 0.05$].

Discussion of Findings

The study found that students taught Biology using Computer-Based Instruction (CBI) performed significantly better than those taught using the conventional lecture method. The CBI group recorded a higher mean gain score (36.59) than the lecture group (22.66), and the difference was statistically significant. This indicates that CBI enhanced students' understanding and mastery of Biology concepts more effectively than the conventional method. The finding agrees with Hassan (2016), Kareem (2015), Shah and Khan (2015), and Sharma (2013), who reported that computer-based instructional approaches significantly improved students' academic achievement. It also corroborates more recent studies by Otieno and Wambugu (2023), Mwangi and Ndung'u (2022), Pheediyivah (2025), and Karambu, Omwenga, and Omosa (2025), all of whom found that technology-supported instruction, including virtual laboratories and computer simulations, significantly enhanced students' performance in Biology.

The study also revealed that male students taught Biology using CBI performed significantly better than their female counterparts, with gender exerting a significant influence on academic performance. This finding disagrees with Yaki and Babagana (2016), Abidoye (2015), Salisu (2015), Gambari, Falode, and Adegbenro (2014), Owusu (2024), and Denor and Aziaka (2025), who reported that computer-based instructional strategies were equally effective for both male and female students. However, the finding agrees with Aggarwal and Dutt (2014), Achor, Wude, and Duguryil (2013), and Oludipe (2012), who attributed male students' superior performance under CBI to differences in prior computer exposure, gender stereotypes, and socio-cultural factors that tend to favour males in technology-related learning environments.

Conclusion

Based on the findings of the study, it was concluded that Computer-Based Instruction (CBI) is a more effective instructional strategy than the conventional lecture method for improving senior secondary school students' academic performance in Biology. The study further concludes that gender significantly influences students' academic performance under CBI, with male students demonstrating higher achievement than their female counterparts. Therefore, while CBI enhances students' learning outcomes, deliberate efforts are needed to ensure that both male and female students benefit equally from technology-based instruction.

Recommendations

The following recommendations were made based on the findings of the study.

1. Since Computer-Based Instruction significantly improved students' academic performance compared to the lecture method, Biology teachers should be encouraged and trained to integrate

Computer-Based Instruction into classroom teaching, while government and school administrators should provide the necessary ICT facilities and infrastructure to support its effective implementation.

2. Since gender significantly influenced students' academic performance under Computer-Based Instruction, teachers should adopt gender-responsive instructional strategies and provide equal opportunities, guidance, and access to computer-based learning resources to ensure that both male and female students benefit equally from Computer-Based Instruction.

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