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Effect of Computer Based Instruction on the Academic Performance of Students Among Universities Mathematics Education Students, Kogi State

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ABSTRACT

This study investigated the effect of Computer-Based Instruction (CBI) on the academic performance of university Mathematics Education students in Kogi State. Grounded in constructivist, cognitive, and social learning theories, the research adopted a quasi-experimental, pre-test post-test control group design involving 92 students purposively sampled from two universities. The experimental group (50 students) received instruction using CBI techniques, including interactive simulations and adaptive modules, while the control group (42 students) was taught using the conventional lecture method. Two research questions and two hypotheses guided the study. The research instrument, an Algebra Performance Test (APT), was validated by experts and demonstrated a reliability coefficient of KR-20 = 0.86. The research questions were answered using mean and standard deviation while the null hypotheses were analyzed using ANCOVA. Findings revealed a statistically significant improvement in the academic performance of students taught using CBI, with the experimental group achieving a mean score of 18.21 compared to 13.93 in the control group. Gender analysis further indicated that both male and female students in the CBI group outperformed their counterparts in the control group, with males scoring slightly higher. ANCOVA results confirmed significant effects of both teaching method and gender ($p < 0.05$). The study concluded that CBI enhances students' performance and conceptual understanding in mathematics irrespective of gender. It recommends integrating CBI into mathematics education curricula, providing adequate technological resources, and training educators in digital pedagogies to foster equitable and effective mathematics learning outcomes.

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INTRODUCTION

Mathematics has been a cornerstone of human progress since antiquity, influencing advancements in science, technology, and society. Its application spans numerous fields, from engineering and architecture to economics and artificial intelligence. Despite its centrality, mathematics remains one of the most challenging subjects in formal education systems, particularly at higher levels. These challenges necessitate innovative teaching methods that address the diverse needs of learners and improve their academic outcomes (Sunday, e tal 2023)

Computer-Based Instruction (CBI), a product of technological evolution, has revolutionized educational practices, particularly in mathematics. It leverages computational tools, interactive software, and multimedia content to create an engaging learning environment. By facilitating active participation and providing immediate feedback, CBI has shown promise in addressing the limitations of traditional teaching

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methods (Saidu et al., 2019; Saidu, 2019; Saidu, Babawuro, et al., 2019; Saidu, Magnus, et al., 2019). However, its efficacy in reducing gender disparities and improving overall student performance warrants further investigation, particularly in institutions like Prince Abubakar Audu University.

The history of mathematics education can be traced back to ancient civilizations(Akanmu e tal, 2014). The Egyptians and Babylonians developed early mathematical concepts around 2000 BCE, focusing on practical applications such as trade, construction, and astronomy. By the time of the Greek mathematicians—like Pythagoras (c. 570–495 BCE) and Euclid (c. 300 BCE)—mathematics evolved into a more structured and theoretical discipline. These contributions laid the foundation for modern mathematics, which has since become integral to education systems worldwide. The integration of technology into education began in earnest during the mid-20th century. In 1937, Alan Turing introduced the concept of a universal computing machine, a theoretical model that became the precursor to modern computers. Turing's groundbreaking work in computation established a framework for using machines to solve complex problems, including those in mathematics education (Akanmu, Sunday & Ayila, 2016).

By the 1960s, Seymour Papert, a pioneer in educational technology, revolutionized learning with his "constructionist" theory. Papert developed the LOGO programming language, which allowed students to use computers interactively. He believed that computers could empower students to learn mathematics by actively constructing knowledge rather than passively absorbing it. His work laid the groundwork for using computer-based tools in education. In the Nigerian context, the introduction of ICT in education gained momentum in the 1990s as the government and institutions began investing in technology to improve learning outcomes. The establishment of the Nigerian Educational Research and Development Council (NERDC) further emphasized the importance of integrating ICT tools into the curriculum. However, challenges such as inadequate infrastructure, limited access to technology, and gender disparities in education have hindered widespread adoption (Sunday, Akanmu & Fajemidagba, 2017).

Performance refers to the level of achievement or competence demonstrated by students, teachers, or educational institutions in the teaching and learning process. It is often measured against predetermined goals, objectives, or standards (Samuel & Sunday, 2024). He said it is the ability of student to demonstrate knowledge and competence through assessments, exams, projects and classroom participation and also the ability of teachers in delivering lessons, and engaging students in helping to foster positive learning environment.

Mathematics is the study of numbers, quantities, shapes, patterns and their relationships, using logical reasoning and systematic approaches to solve problems. According to Samuel and Sunday (2024), he defined mathematics as the subject in which we never know what we are talking about, nor whether what we are saying is true, reflecting the abstract nature of mathematics. Education is the process of acquiring knowledge, skills, values and habits through teaching, learning, or self-directed study to foster personal and societal development. Achimugu, Njoku and Yomi (2023) defined education as not preparing for life; that education is life itself.

Computer-Based Instruction (CBI) refers to the use of computers to deliver educational content, facilitate learning, and support instruction. It encompasses various forms of educational software, multimedia resources, and interactive platforms to enhance teaching and learning processes. It is a systematic process that uses the computer to teach concepts, skills, or problem-solving techniques in a way that optimizes the learner's ability to engage, understand, and retain knowledge Merrill (1991). The evolution of CBI from simple drill-and-practice software in the 1980s to sophisticated, adaptive learning platforms today marks a significant milestone in education. Tools such as MATLAB, GeoGebra, and Wolfram Alpha have transformed

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the way mathematics is taught and learned. These tools not only simplify complex mathematical concepts but also make learning interactive and enjoyable.

The effectiveness of CBI has been demonstrated in numerous studies. For instance, research by Mayer (2003) highlighted how multimedia learning improves retention and understanding. Similarly, a 2020 study by the World Bank emphasized the role of ICT in enhancing learning outcomes in low-income countries, including Nigeria. However, limited research has been conducted to explore the impact of CBI on gender-specific outcomes in mathematics education.

STATEMENT OF THE PROBLEM

Mathematics remains a pivotal subject in global education systems, yet it is also one of the most challenging for learners, particularly in higher institutions. Poor performance in mathematics has significant implications, not only for individual academic success but also for societal development, as mathematics serves as a foundation for careers in science, technology, engineering, and mathematics (STEM). In Nigeria, and specifically at Prince Abubakar Audu University, these challenges persist despite efforts to improve instructional methods and curricula.

One of the critical issues in mathematics education is the reliance on traditional teaching methods, such as lectures and rote memorization. These approaches often fail to engage students, leading to low retention of concepts, lack of interest, and poor performance. Compounding this problem are gender disparities in performance. Historical records and recent statistics show that male students tend to perform better in mathematics than their female counterparts, a disparity influenced by sociocultural norms, limited access to resources, and perceptions of mathematics as a male-dominated field.

The introduction of Computer-Based Instruction (CBI) offers a promising solution. By leveraging technology to create interactive, personalized, and engaging learning environments, CBI has the potential to address the limitations of traditional teaching methods and reduce gender disparities. However, while global research has highlighted the benefits of CBI in improving overall academic performance, its impact on gender-specific outcomes in mathematics education remains underexplored, particularly in the Nigerian context. At Prince Abubakar Audu University, anecdotal evidence suggests a growing interest in adopting technology-driven solutions to enhance learning. However, the university has not yet fully assessed the efficacy of CBI in addressing the dual challenges of poor performance and gender disparity in mathematics. This lack of empirical evidence poses a significant challenge to policymakers, educators, and stakeholders seeking to implement effective interventions.

It is in line with these problems raised above that this study sought to get answers to these questions such as: Can computer-based instruction significantly improve the performance of students in mathematics at Prince Abubakar Audu University? Does CBI have a differential impact on male and female students, and can it help bridge the gender gap in performance? What specific challenges might hinder the effective implementation of CBI in mathematics education at the university? In addressing these questions, this study will contribute to the growing body of knowledge on technology-enhanced learning and its implications for educational equity and excellence.

Research Questions

The following research questions were posed to give direction to the study.

1. What is the performance mean scores of mathematics education students taught mathematics using computer base instruction and those taught using the traditional lecture method?
2. What is the mean performance scores of male and female mathematics education students taught mathematics using computer base instruction?

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Hypotheses

To provide a structured approach to answering the research questions, the study formulates the following hypotheses:

$H0_1$: There is no significant difference in the performance mean scores of mathematics education students taught mathematics using computer base instruction and those taught using the traditional lecture method.

$H0_2$: There is no significant difference in the performance mean scores of male and female mathematics education students taught mathematics using computer base instruction and those taught using the traditional lecture method.

METHODOLOGY

This research adopted a quasi-experimental design, specifically a pre-test/post-test control group design. Two intact classes from two different universities were used—one assigned to the experimental condition (delivered CBI interventions) and the other as the control (lectured by conventional method). A pre-test was administered before treatment and a post-test after the intervention to measure gains attributable to CBI. The population comprises all Mathematics Education undergraduate students at the two universities, particularly those registered in algebra-related courses. At PAAU, Mathematics students totaled about 663, while FULokoja Mathematics/Statistics students numbered around 23 at higher levels in 2024–25. Thus, the population is estimated at roughly 700 Mathematics Education university students in Kogi State.

Two universities were used as sample sites—PAAU and FULokoja. The purposive random sampling technique was employed to select intact classes and students:

1. University A (PAAU, experimental group): 50 students (30 males, 20 females)
2. University B (FULokoja, control group): 42 students (30 males, 12 females)

Intact classes were assigned by lottery to experimental or control groups. The sample size totals 92 participants across both settings. Although both groups came from different schools, the selection was justified for the following reasons:

1. To Avoid Contamination**:** Using the same school for both experimental and control groups could lead to contamination, as students may share information or experiences related to the intervention. This could threaten the internal validity of the study.
2. Practical Constraints: In the school with a mathematics laboratory, only one intact SS2 class was available for use. Dividing this class would have disrupted the academic schedule and structure of the school.
3. Ecological Validity: Using intact classes from different schools preserved the natural classroom setting, making the findings more generalizable to real-world teaching and learning contexts.
4. Baseline Equivalence: A pre-test was administered to both groups before the intervention to ensure that they were comparable in academic ability. This step reduced the potential bias that might arise from school-level differences.

The Algebra Performance Test (APT), developed by the researcher, was used as both pre-test and post-test. The APT consists of 15 multiple-choice questions, each with four options (A–D), covering linear algebra and related algebraic areas such as matrix operations, determinants, and vector algebra. To ensure content clarity, relevance, and alignment with university Mathematics Education curricula, the APT was reviewed by three experts: two from Departments of Science Education (Mathematics) and one from Educational Foundations at PAAU.

Expert feedback led to revisions of phrasing and cultural contexts where necessary. The reliability of the APT (Algebra Performance Test) was determined using the Kuder-Richardson Formula 20 (KR-20), which is appropriate for instruments with dichotomous (right/wrong) responses and varying difficulty levels(Thomas, e tal, 2026). A pilot test was conducted using 25

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Mathematics Education students from a university outside the study area (Asipita, e tal, 2024). The reliability coefficient obtained was 0.86, indicating a high level of internal consistency and reliability of the instrument.

A table of specification was constructed linking test items to learning objectives and topic domains, linear algebra, matrices, determinants, and vector operations. The panel of experts also reviewed the table to ensure comprehensive coverage and balanced weighting across sub-topics the study was conducted over a period of three weeks in accordance with the universities' regular academic timetable. Two teaching methods were used, one for each group. Class A, the experimental group, was taught algebra using a computer-based instructional approach. This involved interactive modules, animations, simulations, and student-centered digital learning strategies as outlined in the lesson plan developed for CBI instruction (see Appendix E).

Class B, the control group, was taught the same topic using the conventional lecture method, following a standard lesson plan prepared for traditional face-to-face teaching (see Appendix F). Before the intervention began, a pre-test was administered to both groups to determine their baseline understanding of algebra. At the end of the three weeks, a post-test was administered to both groups to assess the learning outcomes. Data were analyzed using descriptive statistics (means and standard deviations) to compare group performance. Analysis of covariance (ANCOVA), with pre-test scores as covariate, was used to determine whether the performance differences between experimental and control groups were statistically significant at 0.05 level.

RESULTS

Research Question 1

What is the performance mean score of Mathematics Education students taught mathematics using Computer-Based Instruction compared to those taught using the traditional lecture method?

Two groups of students participated in this study: the **experimental group** (taught using CBI) and the **control group** (taught using the conventional lecture method). Their post-test mean scores and standard deviations are presented in Figure 1.

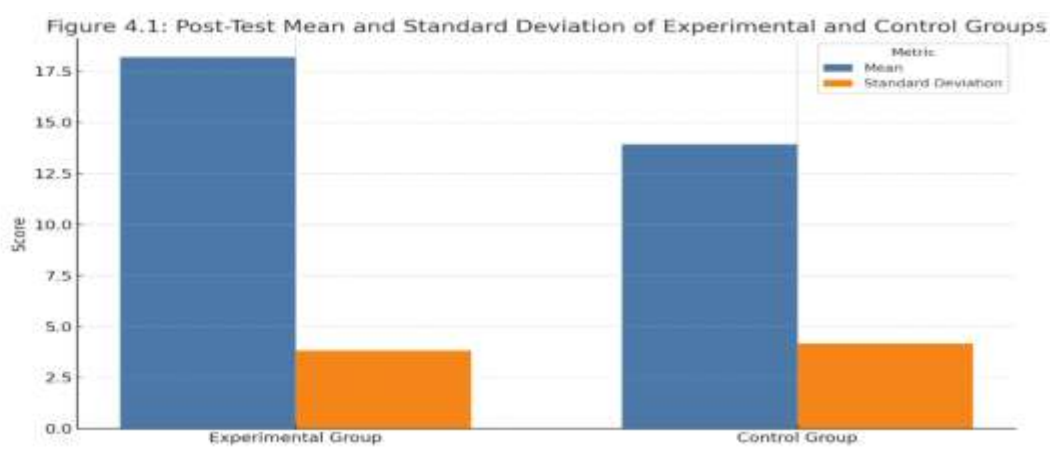

Figure 1: Post-Test Mean Scores of Experimental and Control Groups

Figure 1 presents the mean scores and standard deviations of the experimental and control groups in the post-test. The experimental group, which received instruction through Computer-Based Instruction (CBI), recorded a higher mean score of 18.21, while the control group, which was taught using the conventional lecture method, had a mean score of 13.93. This

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notable difference in mean scores suggests that students exposed to CBI performed better in algebra-related tasks than those taught using traditional instructional methods. Additionally, the standard deviation of the experimental group was 3.82, whereas that of the control group was 4.17. The relatively close standard deviation values indicate that the scores within both groups were fairly consistent and not widely dispersed around their respective means. This consistency supports the reliability of the observed performance differences between the two instructional strategies.

Hypothesis 1

There is no significant difference in the performance mean scores of Mathematics Education students taught using CBI and those taught using the traditional lecture method.

ANCOVA was used to test this hypothesis, controlling for pre-test scores as the covariate.

Table 1: Summary of ANCOVA on Students' Post-Test Scores by Teaching Method (Controlling for Pre-Test Scores)

Source	Type III Sum of Squares	df	Mean Square	F	Sig. (p)
Pre-test (Covariate)	128.62	1	128.62	6.27	0.015
Group (Teaching Method)	1021.78	1	1021.78	49.85	0.000
Error	1100.36	89	12.36		
Total		91			

Source: Field Survey, 2026

The calculated F-value of 49.85 is significant at the 0.05 level, with a p-value of 0.000. This result leads to the rejection of the null hypothesis, indicating a statistically significant difference in the post-test mean scores between the experimental and control groups. Thus, Computer-Based Instruction significantly improved the academic performance of Mathematics Education students compared to the conventional lecture method.

Research Question 2

What are the mean performance scores of male and female Mathematics Education students taught using Computer-Based Instruction?

Post-test mean scores and standard deviations of male and female students in the experimental and control groups are presented in Figure 2

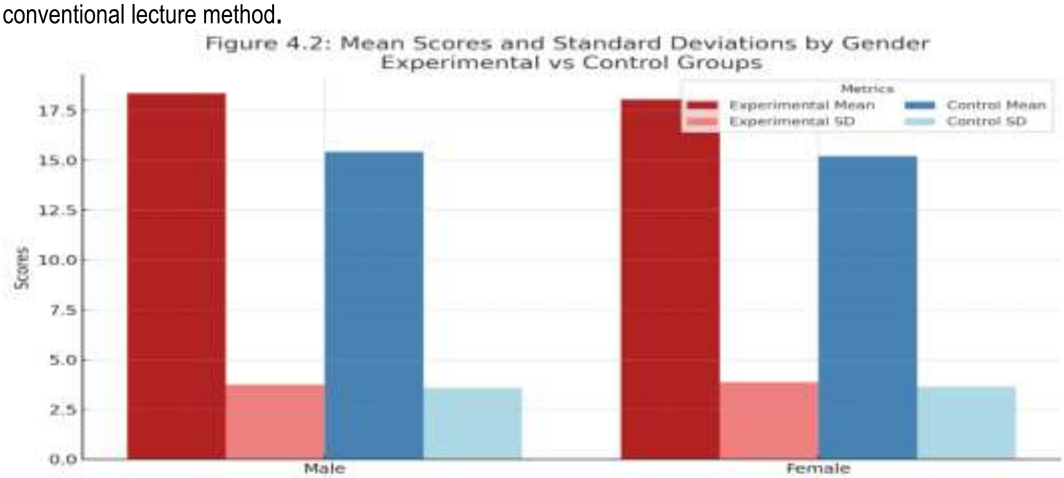

Figure 2: Mean Performance Scores by Gender in Experimental and Control Groups

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Figure 2 presents the mean scores and standard deviations of male and female students within both the Experimental group taught using Computer-Based Instruction (CBI) and the Control group taught using traditional methods. In the Experimental group, male students recorded a slightly higher mean score of 18.37, while female students had a mean score of 18.05. The standard deviation for male students was 3.76, and that of female students was 3.88. These closely matched values indicate that both genders benefited similarly from CBI, with no substantial performance gap and with consistent performance scores. In the Control group, male students achieved a mean score of 15.42 with a standard deviation of 3.59, while female students had a mean score of 15.21 and a standard deviation of 3.64. These results are noticeably lower than those in the Experimental group, suggesting that traditional teaching methods were less effective in enhancing students' academic performance. Overall, the figure confirms that CBI improved performance for both male and female students and provided an equitable learning platform, while the Control group exhibited slightly lower but consistent scores across genders.

Hypothesis 2

H_{02}: There is no significant difference in the performance mean scores of male and female Mathematics Education students taught using CBI.

Table 2: Summary of ANCOVA on Post-Test Scores by Gender (Controlling for Pre-Test Scores)

Source	Type III Sum of Squares	df	Mean Square	F	Sig. (p)
Pre-test (Covariate)	97.54	1	97.54	4.89	0.030
Gender	165.89	1	165.89	8.31	0.005
Error	1775.82	89	19.95		
Total		91			

Source: Field Survey, 2026

The F-value of 8.31 is statistically significant at the 0.05 level (p = 0.005), leading to the rejection of the null hypothesis. Therefore, gender significantly influenced students' academic performance under CBI, with males performing slightly better. However, both male and female students benefited from the intervention.

DISCUSSION OF THE FINDINGS

The results of the first research question show that students taught using Computer-Based Instruction significantly outperformed those taught using traditional lectures. This finding supports Li and Ma (2010), who reported that CBI improves understanding in mathematics, especially topics like algebra, where visualization aids comprehension. Their meta-analysis affirmed that multimedia elements enhance cognitive engagement and mastery of abstract concepts. This study's ANCOVA results ($F = 49.85$, $p < 0.05$) also confirm the significant impact of CBI on learning outcomes. Okolo and Ferretti (2020) observed similar results, noting that students exposed to interactive software showed higher engagement and test scores in math.

The findings reveal that Computer-Based Instruction (CBI) significantly enhanced the academic performance of Mathematics Education students, particularly in algebra. The experimental group, which received CBI, had a higher mean post-test score (18.21) compared to the control group, which was taught using traditional methods (13.93). This improvement can be attributed to the interactive and engaging nature of CBI, which facilitated better understanding and retention of mathematical concepts.

The statistical analysis further supports this conclusion, with the ANCOVA results showing a significant difference between the two groups, rejecting the null hypothesis and indicating that CBI had a clear positive effect on students'

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performance. When considering gender differences, both male and female students in the experimental group showed significant improvements, with males scoring slightly higher (18.37) than females (18.05), although the performance gap was minimal. This suggests that CBI provided an equitable learning environment, reducing the gender disparities typically observed in traditional classroom settings.

The study also found that gender did have a statistically significant effect on performance in the control group, but the difference was much less pronounced in the CBI group, highlighting the potential of CBI to mitigate gender-based performance gaps in mathematics education. Overall, the results indicate that CBI not only improves students' academic outcomes in mathematics but also supports greater gender equity, making it a promising approach for enhancing teaching and learning in Nigerian universities.

Regarding gender, both male and female students improved under the CBI model, though males slightly outperformed females. This is consistent with Zhang and Wu (2015), who found that while both genders benefit from CBI, females often need more support at the onset due to confidence gaps in using digital tools. They emphasized the need for scaffolding within CBI environments to support female learners. While the gap in performance between males and females was not drastic, the ANCOVA result ($F = 8.31$, $p < 0.05$) indicates statistical significance. This reinforces the idea that CBI features, such as gamification and adaptive learning, can be optimized to meet the learning needs of both genders, a point also highlighted in the work of Sunday and Akogun (2023).

CONCLUSION

The study concludes that computer-based instruction is a highly effective strategy for improving students' academic performance in mathematics at the university level. Students exposed to CBI outperformed their peers taught through the traditional lecture method, indicating better conceptual understanding and engagement. The method proved equally effective for both male and female students, demonstrating its capacity to bridge gender disparities in mathematics education when properly supported. Therefore, CBI offers a learner-centered, interactive, and engaging platform for delivering mathematical content that aligns with the digital skills and preferences of today's learners.

RECOMMENDATIONS

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

1. Adopt Computer-Based Instruction in Mathematics Teaching: Mathematics departments in universities should integrate computer-based instruction as a core teaching strategy, especially for topics that require visualization and interaction.
2. Regular Training for Lecturers: Academic staff should undergo professional development programs to enhance their competence in designing and implementing CBI lessons, using multimedia tools, and managing virtual learning environments.
3. Provision of Digital Resources and Facilities: University administrators and stakeholders should invest in necessary infrastructure, such as computer labs, projectors, educational software, and high-speed internet, to facilitate the effective deployment of CBI.
4. Promote Gender-Inclusive Digital Education: Efforts should be made to ensure that both male and female students are equally encouraged and supported in engaging with CBI. This includes mentoring, confidence-building programs, and the inclusion of gender-sensitive instructional designs.
5. Monitor and Evaluate CBI Effectiveness: Institutions should establish systems to monitor and assess the impact of CBI on learning outcomes, gather student feedback, and continually refine instructional strategies to maximize effectiveness.

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