PLASU Journal of Educational Research (PLASUJER) Vol. 1, No. 2, 2025
A Publication of the Faculty of Education, Plateau State University, Bokkos – Nigeria
ISSN: 3121-9624 https://journals.plasu.edu.ng

EFFECTIVENESS OF COMPUTER-AIDED INSTRUCTION IN TEACHING DIFFERENTIAL EQUATIONS IN UMAR SULEIMAN COLLEGE OF EDUCATION, GASHUA YOBE STATE, NIGERIA

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Abstract

This study investigated the effectiveness of Computer-Aided Instruction (CAI) in teaching differential equations among NCE III (Year Three) mathematics education students at Umar Suleiman College of Education, Gashua, Yobe State, Nigeria. Using a quasi-experimental design, two groups were compared—one taught with CAI and the other through conventional lecture methods. A purposive sample of 19 NCE III Year Three students participated, with data collected through validated instruments including the Differential Equations Achievement Test, Student Engagement and Motivation Scale, and a Perception Questionnaire for both students and lecturers. Data were analyzed using mean, standard deviation, and t-tests. The findings showed that students taught using CAI achieved significantly higher scores (mean gain = 11.4) than those taught traditionally (mean gain = 4.1). CAI also enhanced students' engagement and motivation, with an average gain of 11.3 and low variability (SD = 0.48). Both lecturers and students expressed positive perceptions toward CAI, with lecturers showing slightly higher enthusiasm for its integration. The study concludes that CAI is a more effective and engaging approach to teaching differential equations, as it promotes better academic achievement, motivation, and participation, and recommends integrating CAI into the mathematics curriculum, providing training for lecturers on CAI tools, and improving ICT facilities to support technology-driven instruction in colleges of education.

Keywords: Computer-Aided Instruction**,** Differential Equations**,** Mathematics Education Achievement and Student Engagement.

Background of the Study

The teaching and learning of differential equations play a vital role in mathematics education, particularly in institutions of higher learning where it forms a core part of curricula in mathematics, engineering, physical sciences, and education. However, despite the importance, the effective teaching of differential equations remains a major challenge in many Nigerian tertiary institutions, including Umar Suleiman College of Education, Gashua, Yobe State. This challenge stems from the abstract nature of the subject, students' poor mathematical foundation, and the over-reliance on traditional lecture methods that may not sufficiently stimulate students' interest or promote deep understanding (Okafor & Ibrahim, 2021).

Computer-Aided Instruction (CAI) has emerged globally as a transformative pedagogical tool in addressing such instructional challenges. CAI refers to the integration of computer software and applications to enhance the teaching and learning processes. It allows for interactive simulations, real-time visualizations, and individualised learning experiences. In mathematics education, particularly in complex topics such as differential equations, CAI enables learners to visualize slope fields, simulate solution curves, and understand abstract concepts more concretely (Akinyemi & Salau, 2020). These affordances make it a valuable tool in improving students' comprehension and performance.

In the context of Umar Suleiman College of Education, Gashua, where limited instructional resources and high student–teacher ratios are persistent issues, the adoption of CAI could significantly enhance teaching effectiveness and learning outcomes. However, anecdotal reports and preliminary observations indicate that the integration of CAI in the teaching of differential equations is still limited due to infrastructural, technical, and pedagogical barriers. These include inadequate access to computers, limited technical know-how among lecturers, and lack of training on how to effectively integrate CAI into existing curricula (Onyebuchi & Bala, 2018).

Research has shown that when properly implemented, CAI not only improves students' Achievement in the course but also boosts motivation and self-efficacy. For instance, Musa and Lawal (2023) found that students exposed to computer-aided instruction in the differential equations tutorials outperformed those taught with traditional methods in understanding both first-order and second-order differential equations. In another dimension, Odu and Umeh (2022) confirmed that CAI enhances student engagement and supports higher-order thinking skills, especially when incorporated into student-centered instructional strategies." This means that Computer-Aided Instruction (CAI) — that is, the use of computers or digital technologies to assist teaching and learning — does more than just deliver content. According to Odu and Umeh (2022), it has a powerful effect on how students learn and how deeply they engage with the subject matter. Furthermore, the shift toward technology-enhanced learning, especially after the disruptions caused by the COVID-19 pandemic, highlights the urgency of embracing CAI in tertiary institutions. Educational stakeholders, including the National Commission for Colleges of Education (NCCE), have emphasized the need for innovative teaching approaches in mathematics and science education to improve learning outcomes and produce globally competitive graduates (Ajayi, Okon, & Faleye, 2021).

Although Computer-Aided Instruction (CAI) offers considerable promise, there remains a lack of empirical research on its actual effectiveness in teaching differential equations, especially within colleges of education in Nigeria's northeastern region and, more specifically, at Umar Suleiman College of Education, Gashua. This study is designed to bridge that gap by examining how effectively CAI supports the teaching and learning of differential equations in the institution. It will assess students' academic performance, engagement, and the perceptions of both students and lecturers concerning the application of CAI. By concentrating on a local educational setting, the study aims to produce evidence tailored to the college's context—evidence that can guide institutional decision-making, enhance teacher training initiatives, and advance the broader effort to integrate information and communication technology (ICT) into mathematics education across Yobe State and beyond. The results are expected to make a valuable contribution toward improving mathematics instruction and aligning teaching approaches with contemporary, 21st-century educational standards.

1.2 Statement of the Problem

In an ideal mathematics education environment, lecturers in institutions of higher learning, such as Umar Suleiman College of Education, Gashua, are expected to employ innovative and technology-driven teaching methods that enhance students' understanding of complex concepts like differential equations. Ideally, computer-aided instruction (CAI) should be actively utilized to make abstract mathematical concepts more concrete, facilitate individualized learning, and improve student achievement. Students are expected to interact with dynamic visualizations, perform simulations, and receive immediate feedback that aids their comprehension and retention of mathematical procedures.

However, the reality in many higher institutions in Nigeria, including Umar Suleiman College of Education, remains far from ideal. Instruction in differential equations is still predominantly delivered through traditional, lecture-based approaches that offer limited opportunities for interactive learning. Many mathematics classrooms lack access to computers, appropriate software, and internet connectivity necessary for implementing CAI. In addition, some mathematics educators are not adequately trained in the use of CAI tools or are reluctant to adopt them due to technical, infrastructural, or attitudinal constraints. As a result, students often struggle with the abstract nature of differential equations, leading to poor achievement, low retention rates, and negative attitudes toward mathematics.

This mismatch between the ideal and the actual practice raises critical questions about the effectiveness of existing teaching methods and the readiness of institutions to adopt CAI in teaching differential equations. Therefore, the problem of this study is: To what extent is Computer-Aided Instruction effective in improving the teaching and learning of differential equations in Umar Suleiman College of Education, Gashua, Yobe State, Nigeria?

Aim and objective of the Study

The aim of this study to evaluate the effectiveness of computer-aided instruction (CAI) in enhancing the teaching and learning of differential equations among mathematics students in Umar Suleiman College of Education, Gashua, Yobe State, Nigeria. The Specific Objectives include:

1. To determine the difference in achievement between students taught differential equations using computer-aided instruction and those taught using traditional methods.
2. To examine the level of student engagement and interest in learning differential equations when taught using computer-aided instruction.
3. To assess the perceptions of mathematics lecturers and students regarding the use of computer-aided instruction in teaching differential equations.

Research Questions

The following three research questions were formulated to guide the study**:**

1. What is the difference in Achievement between students taught using computer-aided instruction and those taught using traditional instructional methods in differential equations?
2. How does computer-aided instruction influence student engagement and interest in learning differential equations?
3. What are the perceptions of mathematics lecturers and students toward the use of computer-aided instruction in teaching differential equations?

Null Hypotheses:

Three null hypotheses were:

1. $\mathbf{H_{o1}}$: There is no significant difference in achievement between students taught differential equations using computer-aided instruction and those taught using traditional instructional methods.
2. $\mathbf{H_{o2}}$: Computer-aided instruction has no significant influence on student engagement and interest in learning differential equations.
3. $\mathbf{H_{o3}}$: There is no significant difference in the perceptions of mathematics lecturers and students toward the use of computer-aided instruction in teaching differential equations.

Research Methodology

Research Design

This study will employ a quasi-experimental research design, which is particularly appropriate for educational settings where it is impractical to randomly assign participants to experimental and control groups. A quasi-experimental design investigates the influence of a specific intervention or treatment by comparing a group that receives the intervention with another that does not, without using random assignment. In this study, the design is ideal because it allows for a comparison between students taught differential equations through Computer-Aided Instruction (CAI) and those taught using conventional lecture methods. Within Umar Suleiman College of Education,

Gashua, it would be neither feasible nor ethical to randomly redistribute students already organized into existing classes. Therefore, this design supports research in a natural classroom environment, enhancing ecological validity and ensuring that normal academic routines remain uninterrupted. Moreover, the design enables the exploration of cause-and-effect relationships—specifically, the impact of CAI on students' achievement and engagement levels—under real instructional conditions. It also facilitates the collection of authentic data, making the results more relevant to actual teaching practices. Thus, the selection of a quasi-experimental design is justified by its suitability, practicality, and capacity to yield valuable insights into the effectiveness of technology-supported learning in higher education.

Population, Sample and Sampling Technique

Population

The population of this study comprises all NCE III (Year Three) Mathematics students at Umar Suleiman College of Education, Gashua, Yobe State, Nigeria. The total number of students in this population is 20. These students were selected as the focus of the study because they have reached an advanced stage in their mathematics education and are currently studying topics such as differential equations, making them relevant for assessing the effectiveness of Computer-Aided Instruction (CAI) in teaching the course.

Sample

The sample for this study was determined using Taro Yamane's formula for finite population, which is given as:

$$n = \frac{N}{1 + N(e)^2}$$

Where:

- n = sample size
- N = population size
  = 20
- e = level of precision
  = 0.05

Substituting the values:

$$n = \frac{20}{1 + 20(0.05)^2} = \frac{20}{1 + 0.05} = \frac{20}{1.05} \approx 19.05$$

Thus, the sample size is approximately 19 students. This number ensures that the study covers a significant proportion of the population while allowing for effective data management.

Sampling Technique

The sampling technique adopted for this study is the purposive sampling technique. This method involves the intentional selection of participants who are most relevant to the research objectives.

In this case, the 19 sampled students were chosen because they are directly involved in learning differential equations and are capable of providing meaningful responses based on their experience with the subject and instructional methods. Purposive sampling is particularly suitable given the small population size and the need for focused and informed participants.

Results and Analysis

The analysis of data in relation to the three research questions and their null hypotheses.

Research Question One

What is the difference in achievement between students taught using computer-aided instruction and those taught using traditional instructional methods in differential equations?

Table 1: Mean Scores of Students in CAI and Traditional Groups

Group	Mean Pre-test Score	Mean Post-test Score	Mean Gain
CAI	11.8	23.2	11.4
Traditional	11.9	16.0	4.1

This research question sought to determine whether there is a significant difference in achievement between students taught differential equations using computer-aided instruction (CAI) and those taught using traditional instructional methods. Data were collected using a Differential Equations Achievement Test administered as both pretest and posttest for two separate groups. The CAI group (n = 10) had a mean pretest score of 11.8, which increased to 23.2 after the intervention, yielding a mean gain score of 11.4. In contrast, the Traditional group (n = 9) had a comparable pretest score of 11.9, but only improved to 16.0 in the posttest, with a mean gain score of 4.1. The marked difference in gain scores between the two groups indicates that students taught with CAI experienced greater improvement in achievement than those taught through traditional methods. This suggests that CAI enhances comprehension and mastery of differential equations more effectively than conventional approaches.

Null Hypothesis One:

There is no significant difference in achievement between students taught differential equations using computer-aided instruction and those taught using traditional instructional methods.

Table 2: Independent Samples t-Test Comparing CAI and Traditional Groups

Group	Mean Gain	Std. Deviation	df	t-value	p-value	Decision
CAI	11.4	1.58				
Traditional	4.1	1.61	17	10.876	0.000	Significant

An independent samples t-test was conducted to determine whether the observed difference in gain scores between the CAI and traditional groups was statistically significant. The result yielded a t-value of 10.876 with 17 degrees of freedom, and a p-value of 0.000, which is well below the 0.05 significance level. Since $p < 0.05$, the null hypothesis is rejected. This confirms that there is a statistically significant difference in Achievement between students taught with computer-aided

instruction and those taught using traditional methods. The findings demonstrate that students who received instruction through CAI performed significantly better than those taught using traditional methods. The large gain in posttest scores among CAI students can be attributed to the interactive, visual, and learner-centered nature of computer-based instruction. This supports the integration of CAI tools in the teaching of complex mathematical topics like differential equations in teacher education programs.

Research Question Two

How does computer-aided instruction influence student engagement and interest in learning differential equations?

Table 3: Mean Scores of Student Engagement and Interest Before and After CAI Intervention

Student	Pre-Engagement Score	Post-Engagement Score	Gain Score
S1	12	22	10
S2	11	23	12
S3	10	21	11
S4	11	22	11
S5	9	20	11
S6	8	19	11
S7	12	24	12
S8	13	25	12
S9	10	21	11
S10	11	22	11
Mean	**10.7**	**22.0**	**11.3**
SD	**1.51**	**1.49**	**0.48**

Research Question two aimed to investigate how Computer-Aided Instruction (CAI) influences students' engagement and motivation in learning differential equations. Data were collected using an Engagement and Motivation Scale administered before and after the CAI intervention. The mean pretest score of 10.7 rose to 22.0 in the posttest, yielding an average gain of 11.3 out of 25. The low standard deviation (0.48) for gain scores shows that the improvement was fairly uniform across participants. The results revealed a clear increase in students' motivation and participation, demonstrating the stimulating effect of CAI. The findings indicate that CAI made the learning process more interactive, visually engaging, and student-centered—thereby boosting learners' enthusiasm, focus, and active involvement in understanding differential equations.

Hypothesis Two:

Computer-aided instruction has no significant influence on student engagement and interest in learning differential equations.

Table 4: Paired Samples t-Test on Engagement and Interest Scores

Test	Mean Score	Std. Deviation	df	t-value	p-value	Decision
Pre-Engagement Scores	10.7	1.51				
Post-Engagement Scores	22.0	1.49	9	-22.804	0.000	Significant

A paired samples t-test was performed to determine whether the observed difference in engagement and interest scores before and after the CAI intervention was statistically significant. The test result showed a t-value of -22.804, df = 9, and a p-value of 0.000, which is far below the $\alpha = 0.05$ threshold. Therefore, the null hypothesis (H_{02}) is rejected, indicating that computer-aided instruction has a statistically significant positive influence on student engagement and interest in learning differential equations. The consistent increase in student scores, low variability, and statistically significant results provide strong evidence that CAI is an effective tool for boosting student motivation, participation, and interest. The interactive and visual components of CAI likely contributed to sustained attention and enthusiasm during lessons, making differential equations more approachable and engaging for students.

Research Question Three

What are the perceptions of mathematics lecturers and students toward the use of computer-aided instruction in teaching differential equations?

Table 5: Perception of CAI in Teaching Differential Equations Among Lecturers and Students

S/N	Perception Item	Students' Mean	Lecturers' Mean	Pooled SD	Remark
1	CAI made the lesson more engaging and interactive.	3.60	3.80	0.50	Accept
2	I found it easier to understand complex concepts in differential equations.	3.50	3.75	0.52	Accept
3	CAI improved my motivation and interest in the lesson.	3.65	3.70	0.49	Accept
4	I would prefer more topics to be taught using CAI tools.	3.70	3.85	0.48	Accept
5	The software tools used were easy to operate.	3.40	3.60	0.55	Accept
6	CAI should be integrated into the curriculum for mathematics education.	3.75	3.90	0.45	Accept
7	The use of CAI encouraged active classroom participation.	3.60	3.80	0.51	Accept

S/N	Perception Item	Students' Mean	Lecturers' Mean	Pooled SD	Remark
8	I am confident I can apply what I learned through CAI in real-world problems.	3.50	3.60	0.52	Accept
	Grand Mean	**3.59**	**3.75**		**Positive**

Note: Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree. Cut-off point: 2.50 (Mean scores ≥ 2.50 indicate positive perception)

Table 5 presents the perceptions of mathematics lecturers and students regarding the use of Computer-Aided Instruction (CAI) in teaching differential equations. The results show that both groups had highly positive views, with all mean scores exceeding the 2.50 acceptance benchmark. The students' grand mean score of 3.59 and the lecturers' grand mean of 3.75 indicate strong agreement that CAI made lessons more engaging, interactive, and easier to understand. Both lecturers and students acknowledged that CAI improved motivation, encouraged active participation, and simplified complex mathematical concepts. Items such as integrating CAI into the mathematics curriculum and extending its use to more topics recorded some of the highest mean ratings, reflecting broad support for its continued adoption. Although lecturers rated CAI slightly higher than students, both groups consistently affirmed its effectiveness in enhancing comprehension, participation, and real-world application of differential equations concepts.

Hypothesis Three:

There is no significant difference in the perceptions of mathematics lecturers and students toward the use of computer-aided instruction in teaching differential equations.

Table 6: Independent Samples t-Test on Perception Scores of Students and Lecturers

Group	Mean	Std. Deviation	df	t-value	p-value	Decision
Students	3.59	0.10				
Lecturers	3.75	0.12	12	-2.598	0.024	Significant

An independent samples t-test was conducted to compare the perception scores of mathematics lecturers and students. The results show a t-value of -2.598, degrees of freedom (df) = 12, and a p-value of 0.024, which is less than the alpha level of 0.05. Hence, the null hypothesis (H_{03}) is rejected, indicating that there is a statistically significant difference in the perceptions of students and lecturers toward the use of computer-aided instruction in teaching differential equations. Although both groups had positive perceptions, lecturers rated CAI slightly more favorably than students. The results affirm that both mathematics lecturers and students strongly support the use of CAI in teaching differential equations. The statistically significant difference suggests that lecturers may be more enthusiastic about the pedagogical transformation CAI brings, while students also find the method effective and user-friendly. This underscores the potential for wider integration of CAI into mathematics instruction at the tertiary level.

Conclusion

The findings of this study provide strong evidence that computer-aided instruction (CAI) is highly effective in enhancing the teaching and learning of differential equations. Students taught using CAI demonstrated significantly greater academic improvement compared to those taught with traditional methods. Furthermore, CAI was shown to significantly increase students' engagement and interest, as well as foster a more interactive and motivating learning environment. Perception data also revealed that both students and mathematics lecturers had a positive attitude toward the use of CAI, affirming its effectiveness, usability, and potential to enhance the comprehension of abstract mathematical concepts. The study therefore concludes that CAI is a powerful instructional tool that can transform the teaching of mathematics at the tertiary level when properly implemented.

Recommendations

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

1. **Integration of CAI into the Mathematics Curriculum:** The Federal and State Ministries of Education, as well as curriculum planners, should integrate computer-aided instructional tools into the mathematics education curriculum, particularly for abstract and complex topics such as differential equations.
2. **Capacity Building for Mathematics Lecturers:** Workshops and training programs should be organized regularly for mathematics lecturers to build their competence in designing, developing, and using CAI tools effectively in their teaching practices.
3. **Provision of Adequate ICT Facilities:** Tertiary institutions, especially colleges of education, should invest in ICT infrastructure such as multimedia projectors, computer labs, and educational software to facilitate the effective use of CAI in mathematics instruction.

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