A Comparative Study on the Effectiveness of Traditional and Computer-Assisted Instruction Methods in Determining Students’ Achievement on Graph Plotting

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Abstract

The study aimed at examining the effectiveness of traditional and computer-assisted instruction methods in determining students’ achievement on graph plotting in Ethiope East Local Government Area of Delta State, Nigeria. A descriptive survey design was employed and 140 students randomly chosen from the senior secondary schools in the LGA made up the study sample. The chosen students were split into two groups of 70 students each using stratified sampling. The first group served as the experimental group while the second group the control group, were taught graph plotting using computer-assisted instruction and traditional instruction methods respectively. The study took five weeks, and a null and alternative hypothesis was formulated to guide the study. The Teacher Made Test (TMT) on graph plotting was developed as the instrument of the study to assess students’ achievement on graph plotting within the two groups. A reliability of 0.8 was yielded for the instrument using Richard Kuderson-21. The data obtained from the instrument was treated with t-test of independence at p ≤0.05 level of significance, and the results showed that students who received computer-assisted instruction had significantly higher improvement in their mean test scores. The study thus fills a research gap that informs the improvement of the method employed in teaching graph plotting, thereby enhancing students’ performance in secondary school science education. The research recommends the incorporation of computer-assisted instructions in the pedagogy of graph plotting in the science education of secondary school students across Delta State, Nigeria.

Keywords: Graph Plotting, Traditional Instruction Method, Computer-Assisted Instruction Method, Science Education, Students’ Achievement.

Introduction

Graph plotting is an important aspect of secondary school science education in Nigeria and often times, mathematics and physics teachers in Ethiope East Local Government Area (LGA) has been observed to usually engage students in this topic using a traditional method of instruction which mainly applies classroom discussions on a graph board, within a particularly teacher-centered instruction process. While different instructional approaches have proven to provide a meaningful learning experience that is required for a worthwhile science education, the Nigerian student taking lessons in graph plotting seeks to gain scientific knowledge and develop critical thinking ability as may be necessary for data manipulation and interpretation and must be guided through an engaging process, and such that can maximize their achievement in the area. However, the actual implementation of the Nigerian science curriculum generally, has encountered numerous challenges ranging from teacher-related to student-related factors (Nwabuaku, 2023).

Graph plotting in Mathematics and Physics being one aspect of science education that students often perceive to be challenging as indicated by the Chief Examiners Report in the 2022 and 2023 West African Senior School Certificate Examinations in Mathematics and Physics (WAEC 2022, 2023). In 2012 and 2020, the same body also identified students’ inability to correctly choose scale and plot point correctly on graphs. This points a recurrent difficulty in the area of graph plotting in secondary school science education in Nigeria. This notable academic failure of students in graph plotting in mathematics and physics external examinations is thus drawing more concern in the Nigerian secondary school science education and has necessitated a need for this comparative study in a bid to assess an innovative instructional methodology, in comparison to traditional practices. This will help to improve the process of teaching graph plotting while negotiating for better students’ achievement in science education.

Nations that desire to do well in the 21st century field of science and technology must take seriously the fundamental processes which shape how their scientists are formed. This calls for serious attention in the secondary school science education which primarily borders around Mathematics, Physics, Chemistry and Biology. Interestingly, all of these subjects engage the use of graphs in the handling, manipulation and interpretation of experimental data. Graphs are important tools in science education and are usually used for analysing and representing data, their relationships, and functions. They provide a visual representation of numerical information, making it easier to identify patterns, trends, and relationships between variables. In physics, graphs are frequently used to represent experimental data, such as motion, temperature, or electrical current. In mathematics, graphs are used to represent functions, equations, and geometric shapes. Graph plotting is therefore an obvious essential theme in secondary school science education and its pedagogy must not be overlooked if one is to anticipate a well-rounded secondary school science education.

Traditional instruction methods (TIM) in graph plotting rely heavily on class discussions and textbooks, which can be monotonous and boring. Traditional mathematics and physics instructions place great emphasis on pen and paper activities, where students manually plot graphs on plain or graph papers under the guidance and direction of their teacher. Lessani et al., (2017) stated that the common method of teaching mathematics using the traditional instruction method is teacher-centred and giving lectures is the dominant situation. The traditional instructional method is a pedagogical approach that emphasizes the role of the teacher as the main source of
knowledge transmission. It involves the use of textbooks, lectures, and other non-technological methods to teach students. The process is lengthy and demands high level of accuracy, which can be very challenging for some students. However, there is no denying that students’ participation in an educational setting is seen as a key element in assessing the effectiveness of learning, as well as in forecasting their academic achievement (Chen, et al., 2021).

On the other hand, Computer-Assisted Instruction (CAI) offers a variety of interactive tools such as computer simulations, videos, and virtual labs that can make learning more engaging and fun. CAI engages the use of computers and educational software to aid and enhance the process of instruction and learning. It involves the utilization of technology to support teaching and learning activities, providing students with interactive, personalized, and self-paced learning experiences. Computer-Assisted Instruction has revolutionized the education sector by providing various benefits to students and educators through personalized learning, interactivity, flexibility, accessibility, assessment, and feedback that helps to enhance content delivery, individualized remediation, and data-driven instructions. It helps teachers provide effective teaching while allowing learners to study at a pace and in a manner that aligns with their unique learning preferences. Since graphs are visual representations of mathematical and physical relationships which can greatly aid in the understanding of complex concepts, CAI can be engaged to improve the way and manner that students understand its concept.

Foster, et al., (2016) opined that computer-assisted instruction helps students gather and analyse data, develop predictive models, and search for patterns, making learning more interactive and that using computers positively impact student’s motivation, engagement and time management skills. Similarly, Vilardi (2013) observed a noteworthy contrast in the performance and memory retention of math students who received traditional instruction compared to those who received technology-assisted instruction, with the advantage being on the side of the technology-assisted group. Chekour (2017) on the contrary observed that both purely traditional and completely computer-assisted methods of instruction are less effective in mathematics instructions than a combined approach. He further asserted that a hybrid approach is more balanced and exposes students to a combination of both methods which is more effective in enhancing students’ performance.

**Research Questions**

The question posed to direct this study is as follows:

Is there a notable difference between the academic achievement of mathematics and physics students who learned graph plotting using computer-assisted instruction and those taught with traditional instruction method?

**Hypothesis**

The following hypotheses were formulated to guide the study:

1. There is no significant difference between the academic achievement of mathematics and physics students who were taught graph plotting using computer-assisted instruction and those taught with traditional instruction method.

2. There is a significant difference between the academic achievement of mathematics and physics students who were taught graph plotting using computer-assisted instruction and those taught with traditional instruction method.
Materials and Methods

The descriptive survey approach was employed to comparatively examine the effectiveness of computer-assisted and traditional instructional methods in determining mathematics and physics students’ achievement on graph plotting. 140 Mathematics and Physics students were randomly selected from the senior secondary schools in the LGA to form the study sample. The students were divided into two groups of 70 students each to constitute an experimental group and a control group respectively. Both groups were given instructional intervention on graph plotting for five weeks. However, the experimental group was taught using the computer-assisted instruction method which applied computer packages and videos in teaching graph plotting, while the control group was taught using the traditional instruction method which primarily engaged in class discussions without the application of computer or digital packages.

The instrument engaged by the study is the Teacher Made Test (TMT) for graph plotting. The TMT for graph plotting is a 10-item test that seeks to assess students’ ability to choose scales and plot graphs. The content validity of the instruments was ascertained by two Professors of Science Education in the Department of Science Education, Delta State University, Abraka, Nigeria. The reliability of the instrument was ascertained through a standard test-retest procedure using Richard Kudersom-21 which yielded a reliability coefficient of 0.8. T-test of independence was used to determine the difference in the academic achievement of the two groups at p≤ 0.05 level of significance. This statistics helped to develop data that informed the research questions and also addressed the hypotheses of the study.

Ethical Consideration

Before the commencement of the research, the objectives of the study were carefully explained to every participant in the study. Participation in the study was completely optional and no incentives were offered to encourage participation. All the participants who agreed to take part in the study were required to sign a consent form, which informed them about the nature of the study and their rights as a participant. In order to ensure the anonymity of the participants, they were instructed not to write their names on the graph plotting TMT. Instead, a unique serial number was assigned to each participant, which was used to distinguish the achievements of the experimental and control groups. This measure was put in place to protect the participants’ privacy and prevent any potential bias in the analysis of the results.

Results

Table 1. T-Test Analysis of Students’ Achievement in the Teacher Made Test (TMT) on Graph Plotting Between Students Taught with Computer-Assisted Instruction Method (CAIM) and Those Taught with Traditional Instruction Method (TIM)

<table>
<thead>
<tr>
<th>Variables</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>df</th>
<th>T-value</th>
<th>P-value (2TAIL)</th>
<th>T-Crit (2TAIL)</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAIM</td>
<td>70</td>
<td>58.00</td>
<td>20.35</td>
<td>138</td>
<td>5.10</td>
<td>1.099E-06</td>
<td>1.98</td>
<td>Null Hypothesis Rejected</td>
</tr>
</tbody>
</table>
Based on the data presented in Table 1, the t-test conducted to compare the academic achievement of students taught using CAIM and TIM resulted in a p-value of 1.099E-06. This value is lower than the significant value of p≤0.05, indicating a significant difference in academic performance between the two groups. It is clear that students taught with CAIM outperformed those taught with TIM. The analysis also revealed that students taught with CAIM showed a higher mean score of 58.00 compared to the students taught with the TIM who showed a mean score of 43.93 in the test. Therefore, the null hypothesis of the study which states that there is no significant difference between the academic achievement of mathematics and physics students who learned graph plotting using computer-assisted instruction and those taught with traditional instruction method; is hereby rejected. Consequently, the alternative hypothesis which states that there is a significant difference between the academic achievement of mathematics and physics students who learned graph plotting using computer-assisted instruction and those taught with traditional instruction method is hereby upheld. Similarly, these data answers the research question which guided the conduct of this study. Furthermore, the figure below presents a 3-D bar chart showing the analysis of data obtained from the result of the study.

![Figure 1. 3-D Bar Chart Showing the T-Test Analysis of the Two-Samples (CAIM & TIM) Assuming Equal Variances](image-url)

Where the blue bars represents the experimental group, which is the achievement of the group of students who were thought graph plotting using computer-assisted instruction method (CAIM), while the orange bars represents the control group which comprises the achievement of students taught graph plotting following the traditional instruction method (TIM). The chart obviously identifies a significant difference in the
mean achievement of students in the experimental and control group, with the difference in the favour of those within the experimental group.

**Discussion**

The result from the analysis of data which informed this research revealed that mathematics and physics students who were taught graph plotting using the computer-assisted instruction method tend to show improved achievement than those taught using the traditional instruction method. This aligns with the works of Ran and Walter (2022), which discovered a positive statistically significant difference in the mathematics achievement of students taught with technology-based instructional methods. The outcome of this study also conforms with Bai et al., (2023) who showed that despite the cost implications of computer-assisted instruction method of teaching, it still leads to improved students’ academic achievement compared to the traditional instruction method of teacher-centred discussions. However, Chekour (2017) on the contrary observed that both purely traditional and completely computer-assisted methods of instruction are less effective in mathematics instructions except when a combined approach is employed. He posited that a hybrid approach is more balanced and exposes students to a well-rounded pedagogical process and such that their improved performance is highly negotiable.

This study thus bridges a gap in knowledge by rightly informing practitioners, policy makers, and education stakeholders on how to innovatively improve the menace of poor students’ achievement in the graph plotting which constitutes a very essential theme in secondary school science education in Nigeria.

**Conclusion**

The findings of the study suggest that the computer-assisted instruction method is a more effective and engaging method of teaching graph plotting compared to the traditional instruction method. The study therefore reaffirmed that computer-assisted instruction method can lead to higher achievement among mathematics and physics students in graph plotting. It thus bridges an existing gap in knowledge between the preconceived effectiveness of traditional instruction method and computer-assisted instruction method in mathematics and physics students’ pedagogical adaptations on graph plotting.

The study hence posits that by incorporating computer-assisted instructions in mathematics and physics teachings, students are likely to have a better understanding of the subject matter, resulting in improved achievement in these subjects. The integration of technology in the Nigerian secondary school science education is hereby recommended to enhance learning outcomes in sciences, since computer-assisted instruction method offers a promising alternative to traditional instruction method in the graph plotting themes of mathematics and physics lessons. However, the science teacher should consider individual differences in learning styles and adapt their teaching approach and instructional method accordingly. Further studies in this direction can look into students’ preference and readiness to computer-assisted instructions, as well as gender differences in students’ achievement in sciences in a computer-assisted instructional process.
Acknowledgement

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Conflict of interests

The authors declare no conflict of interest.

References


