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Comparative Effects of Lecture Method Blended with Geometric Models and Lecture Method on Students' Achievement and Retention in Mathematics in Delta State

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Abstract
The study investigated the effects of combining the lecture method with geometric models, compared to using only the lecture method, on the achievement and retention of Mathematics knowledge among students in Delta State. A quasi-experimental design was utilised. Students in intact classes were divided into experimental and control groups. The experimental group of students received instruction in mathematics using a combination of the lecture method and the use of geometric models, whereas the control group of students were taught solely through the lecture method without the inclusion of geometric models. This instruction was carried out over a duration of six weeks. The study's population comprised a total of 20,819 students from SSII public schools in Delta State for the 2023/2024 session. The sample size consisted of 222 SSII students. The four schools used for the study were picked using the stratified random sampling technique. The data collection process utilised an achievement test, which has a reliability value of 0.88. The data were examined using t-test and ANCOVA. The findings indicate a significant difference in the mean achievement and retention scores of students who were instructed in Mathematics using a combination of the lecture method and geometric models, compared to those who were taught only using the lecture method. The results favour the use of the lecture method combined with geometric models. It was concluded that incorporating geometric models in mathematics instruction has a positive impact on students' learning outcomes. Thus, it was recommended among others that educators and curriculum designers should consider incorporating geometric models as a regular part of mathematics instruction to enhance students' learning experience.

Keywords: *Lecture Method, Geometric Models, Students' Achievement, Students, Retention, Mathematics*

Introduction

Mathematics is an essential discipline that is taught in schools in Nigeria and holds a pivotal position in the entire education system. This subject is fundamental and equips students with vital skills and knowledge in problem-solving, critical thinking, logic, and mathematical reasoning. The National Policy on Education in Nigeria provides guidance for mathematics education, highlighting the significance of mathematics in educating students with essential mathematical abilities for personal growth and national advancement (Aregbesola & Afolabi, 2020). Mathematics in senior secondary schools in Nigeria is taught by certified instructors who adhere to the curriculum set by NERDC. The curriculum encompasses a diverse array of mathematical subjects, such as algebra, geometry, trigonometry, calculus, statistics, and probability. Students are required to develop both procedural fluency and conceptual understanding in these areas to succeed in their mathematical studies.

Engaging in mathematics education at the secondary school level in Nigeria presents a multitude of substantial benefits (Anibueze, 2015). The discipline of mathematics fosters the cultivation of logical reasoning, problem-solving capabilities and critical thinking proficiencies. It enhances students' ability to analyze and interpret data, make informed decisions, and form logical arguments. These skills are valuable in various aspects of life and future careers. Mathematics equips students with essential numeracy skills. The ability to perform basic calculations, handle money, and understand measurements and quantities is vital for everyday life, personal finance management, and future employment. Many tertiary institutions and professional courses require a strong mathematical background. Studying mathematics in secondary school prepares students for further studies in fields such as engineering, sciences, economics, computer science, and finance. It increases their chances of gaining admission to higher education institutions and broadens their career prospects. Mathematics education often involves the use of technology, such as calculators, spreadsheets, and graphing software. Studying mathematics at the secondary school level helps students become comfortable with utilizing technology for problem-solving and data analysis, preparing them for the digital world. Mathematics has numerous practical applications in everyday life. It helps students understand concepts like budgeting, calculating interest rates, measuring distances, understanding probabilities, and interpreting graphs and charts, facilitating better decision-making and problem-solving in various real-life situations. An extensive understanding of mathematics is essential for the progress and advancement of a nation.

In Nigeria, students' understanding of mathematics is assessed through standardized examinations such as WASSCE. This examination test students' knowledge of mathematical concepts and their ability to apply them to various problems. A review of mathematics students' achievement in WASSCE from 2018 to 2022 has shown that students exhibit poor performance in the subject. In the year 2018, a total of 1,572,396 students registered for the examination. Out of this number, 786,016 students, which is approximately 49.98%, obtained a credit mark in mathematics. In the year 2019, a significant proportion of candidates, specifically 1,309,570 students, obtained a credit in mathematics, accounting for around 82.04% of the total number of candidates who had enrolled for the examination, which amounted to 1,596,161 students. In 2020, 1,003,668 students representing 65.24%, earned credit out of the 1,456,727 students that registered for the examination. 79.7% (1,243,470 students) and 76.36% (1,222,505 students) obtained credit in mathematics in 2021 and 2022, out of 1,560.470 and 1,601,047 students that sat for the examination respectively.

Ijeh (2022) has established a correlation between students' low performance in mathematics and several elements, such as inadequate instructional tactics. My own observations indicate that the lecture approach has traditionally been the main way that mathematics is taught in Nigerian secondary schools. It is an instructional method in which the teacher delivers a presentation of information or concepts to the students. The lecture is typically delivered in a classroom setting, and it may involve the use of visual aids, such as slideshows, charts, diagrams, or videos. The instructor usually speaks for an extended period, and the students are encouraged to take notes. The lecture method is often used in higher education, such as in undergraduate and graduate courses, but it has been predominantly used at the Junior Secondary level of education in recent years. In the lecture strategy, the instructor presents the concepts to be learned to the class. Before instructing, teachers must comprehend various concepts and explain them in the classroom. In the lecture method, the instructor will be actively involved while the students will passively observe. Therefore, students who are instructed using the lecture method may rely on memory and repetition of mathematical topics without fully comprehending them. This could be the underlying reason for the consistent underperformance of students in mathematics. Scholars have advised the use of geometric models, among other methods, to supplement the lecture approach in order to enhance students' low performance in mathematics. Hence, the researcher aimed to determine whether the incorporation of geometric models into the lecture method improves the academic performance and retention of mathematics students compared to the conventional lecture method.

Geometric models are mathematical representations used to describe and analyze real-world objects in geometry (Li & Cohen-Steiner, 2018). These models can take various forms, such as points, lines, polygons, curves, surfaces and solid shapes. Geometric modeling plays a crucial role in various fields, including computer graphics, computer-aided design, architecture, engineering, animation and physics simulations. Geometric models have the potency in enhancing students' achievement and retention in mathematics. Geometric models help students visualize abstract mathematical concepts in a concrete and tangible way. This visual representation could make complex ideas more accessible and easier to understand. By using geometric models, students could develop a deeper understanding of geometric concepts and relationships. The hands-on experience of manipulating shapes and figures helps students grasp the properties and principles of geometry. Working with geometric models requires students to analyze problems, make connections and apply mathematical reasoning (Bostch & Sorkine-Hornung, 2020). This practice enhances their problem-solving skills and fosters a logical approach to mathematical challenges. Geometric models could make mathematics more engaging and interesting for students. The interactive nature of working with shapes and figures could increase motivation and curiosity, leading to higher levels of interest in the subject.

Research has shown that learning through hands-on experiences, such as using geometric models, leads to better long-term retention of information. Students are more inclined to retain geometric concepts when they have actively participated in visual and physical interactions with them. Geometric models promote the development of spatial reasoning skills, which are essential for understanding geometry and other areas of mathematics. These skills are valuable for problem-solving in various STEM fields and everyday life. One study by Huk and Banovic (2020) found that incorporating geometric models into geometry instruction significantly improved students' understanding of geometric concepts and problem-solving skills. The study showed that students who used geometric models in their learning had higher test scores and demonstrated better retention of the material compared to those who did not use such models. Another study by Boulware and Anderson (2017) explored the impact of dynamic geometric software on students' learning and retention in geometry. The researchers found that students who used dynamic geometric software showed greater improvement in their geometric knowledge and skills, and were able to retain the material better over time compared to those who used traditional methods of instruction.

The reviewed studies, although carried out outside Delta State, had shown that geometric models have the potency to raise students' achievement and retention rates. Academic achievement is the accomplishment of learning objectives and goals, usually as indicated by grades, test scores, or other evaluations. Retention on the other hand is a crucial sign of a student's development as a learner and overall academic achievement. Retention is the capacity to retain and apply knowledge that has been acquired over time. Since the capacity to remember and retain information is necessary for long-term learning and comprehension, it is a crucial component of academic success. It is anticipated that using geometric models in addition to lectures could improve students' achievement and retention. In light of this, the investigation of compared the effects of lecture method combined with geometric models and lecture method on the achievement and retention of students in mathematics.

Statement of the Problem

According to a recent study by Ijeh (2022), mathematics student achievement is declining across the country. According to an analysis of the WAEC Chief Examiner's reports of 2018, 2019, 2020, 2021 and 2022, students' consistently low mathematics test scores have been validated. The frightening failure rate necessitates an immediate fix. This failure rate may be explained by the fact that most teachers employ the lecture method of instruction, which causes students to participate passively in both the teaching and learning processes. In addition to making students passive, this teaching approach does not support interactive learning environments where students can actively engage with course materials. Combining geometric models with the lecture technique could help to mitigate this disadvantage. Students' achievement and retention of mathematical concepts may increase when they are exposed to geometric models because it might foster their engagement with resources that improve their conceptualization of basic mathematical concepts. The study's problem is: Will the use geometric models in conjunction with the lecture method improve mathematics students' achievement and retention more than using only the lecture method?

Purpose of the Study

This research generally examined how students' achievement and retention of mathematical knowledge were affected by the lecture method alone versus the lecture method combined with geometric models. The study specifically determined the:

1. effects of lecture method blended with geometric models and lecture method on students' achievement in mathematics;
2. effects of lecture method blended with geometric models and lecture method on students' retention of mathematics.

Research Questions

Two research questions directed the study:

1. What is the difference between the mean achievement scores of students taught mathematics using of lecture method blended with geometric models and lecture method?
2. What is the difference between the mean retention scores of students taught mathematics using of lecture method blended with geometric models and lecture method?

Hypotheses

Two hypotheses further directed the study:

1. There is no significant difference between the mean achievement scores of students taught mathematics using of lecture method blended with geometric models and lecture method.
2. There is no significant difference between the mean retention scores of students taught mathematics using of lecture method blended with geometric models and lecture method.

Methods

In this work, a quasi-experimental design was used. To prevent interfering with regular classroom instruction, intact classroom were employed. An experimental group and a control group were created from these intact classes. For six weeks, the control group's students were taught mathematics using the lecture method without geometric models, while the experimental group's students received instruction using the lecture method combined with geometric models. At the conclusion of the programme, the achievement and retention scores of the two groups of students were compared to determine the effects of the lecture method combined with geometric models and the lecture method on the academic achievement and retention of mathematics in the students. The design of the study is shown in table 3, where O_1, O_2 and O_2 = pretest, posttest and delayed posttest of the experimental group, O_4, O_5 and O_6 = Pretest, posttest and delayed posttest of the control group, X_{LM+GM} = treatment using lecture method blended with geometric models, X_L = treatment using lecture method:

Table 1
Design of the Study

Group	Pretest	Treatment	Posttest	Delayed Posttest
Experimental	O_1	X_{LM+GM}	O_2	O_3
Control	O_4	X_{LM}	O_5	O_6

The study' population comprised 20,819 SSII public schools' students in Delta State for the 2023/2024 session. A sample of 222 SSII students selected from four public mixed secondary schools in Delta State made up the sample size for the study. The four schools for the study were selected using stratified random sampling technique. Mathematics Achievement Test (MAT) was employed in this investigation to gather data. The researcher created the 50-item MAT by using previous WASSCE question papers. MAT was designed to measure mathematics achievement and retention among students. MAT was administered to students as pretest and posttest to measure achievement before and at the end of the six-weeks treatment. Students took the MAT as delayed posttest again four weeks after the six-week treatment period has ended in order to test retention.

Three experts—a mathematics educator from Delta State University, an expert in measurement and evaluation from Delta State University Abraka, and an experienced mathematics teacher from a school in the Okpe Local Government Area of Delta State—conducted the face validity assessment of the MAT. By closely analysing the test items and connecting them to the lessons covered in the six-week lesson plans, they were able to ascertain the MAT's face validity. Their recommendations and corrections were then implemented into the instruments. Using a table of specifications, the MAT's content validity was evaluated. The specification table displayed, according to the amount of time allotted in the lesson plan, the number of things created for each of Bloom's taxonomy's six levels from the mathematics curriculum that were taught. The Kuder-Richardson 21 was utilised to assess the MAT's reliability. This approach was chosen because multiple-choice objective test items with dichotomous natures can benefit from it. Thirty students from a school outside the study's sampled schools in Okpe Local Government Area, Delta State, were given the instrument, and the resulting data were run via Kuder-Richardson 21. A reliability coefficient value of 0.88 was found after examination.

Regarding the actual treatment, the experimental and control groups engaged in the following exercises.

Experimental Group: Teacher clarified the aim of the lesson followed by the presentation of the geometric models to students to prompt students' awareness of relevant knowledge. The instructor then gave the students in the classroom the assignment or the learning resource. The learning materials were clearly organised by the teacher. Students were instructed by the teacher to summarise, identify differences, and connect fresh cases to geometric models. The instructor requested the class to consider any inconsistencies or implication that may be present in the readings or prior knowledge.

Control Group: The teacher began the lesson by reviewing previous work and introduced the day's topic thereafter. The teacher then explained in detail the topic of the day while the students listen. The teacher summarized and evaluated the lesson afterwards.

Before starting treatment, MAT was given as a pretest. After the six-week treatment session, the MAT was rescheduled and administered to the students in the two groups as a posttest and scored. To gauge students' retention, MAT was given again as a delayed posttest four weeks after the first one. In order to address the research questions and evaluate the hypotheses, the data from the pretest, posttest and delayed posttest were analysed.

Results

Research Question 1: What is the difference between the mean achievement scores of students taught mathematics using of lecture method blended with geometric models and lecture method?

Table 2
Mean and Standard Deviation of Pretest and Posttest Achievement Scores of Students Taught Mathematics Using Lecture Method Blended with Geometric Models and Lecture Method

Group	N	Pretest		Posttest		MD	SDD
		Mean	SD	Mean	SD		
Experimental	104	21.81	5.61	66.85	14.27	45.04	8.66
Control	118	22.13	5.80	60.81	14.46	38.68	8.66

MD = mean difference, SDD = standard deviation difference

As shown in Table 2, students in the control group had a pretest mean achievement score of 22.13 with a standard deviation of 5.80, while students in the experimental group had a pretest mean achievement score of 21.81 with a standard deviation of 5.61. On the posttest, students in the experimental group outscored those in the control group; the former had a mean achievement score of 60.81 with a standard deviation of 14.46. The mean score of the experimental group was 66.85, with a standard deviation of 14.27. In addition to a lecture approach, Table 9 showed that the experimental group of pupils also got mathematics education using geometric models. The mean difference for this group was 45.04, whereas the control group's was 38.68.

HO_1: There is no significant difference between the mean achievement scores of students taught mathematics using of lecture method blended with geometric models and lecture method.

Table 3
ANCOVA Summary Comparing Pretest and Posttest Mean Achievement Scores of Students Taught Mathematics Using Lecture Method Blended with Geometric Models and Lecture Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2016.014[a]	2	1008.007	4.859	.009
Intercept	57750.766	1	57750.766	278.362	.000
Pretest	4.279	1	4.279	.021	.886
Methods	2004.961	1	2004.961	9.664	.002
Error	45435.157	219	207.466		
Total	946552.000	222			
Corrected Total	47451.171	221			

Table 3 demonstrates that the computed f is 9.664 with a p-value of 0.002, which is less than 0.05, at the 0.05 level of significance. This demonstrates that there were notable variations in the mean accomplishment posttest results between students who received mathematics instruction via lecture alone and lecture with geometric models. The second null hypothesis is refuted as a result. When students are taught mathematics using both the lecture technique and geometric models, their mean achievement scores are very different from those of students who are taught mathematics using only the lecture method. The best results were obtained by students who learned mathematics through lectures integrated with geometric models.

Research Question 2: What is the difference between the mean retention scores of students taught mathematics using of lecture method blended with geometric models and lecture method?

Table 4
Mean and Standard Deviation of Posttest and Delayed Posttest Scores of Students Taught Mathematics Using Lecture Method Blended with Geometric Models and Lecture Method

Group	N	Posttest		Delayed Posttest		MD	%R = $(\frac{DPM}{PM} x\ 100)$
		Mean	SD	Mean	SD		
Experimental	104	66.85	14.27	61.85	14.27	5.00	92.52
Control	118	60.81	14.46	53.98	13.89	6.83	88.77

MD = mean difference, %R = Percentage Retained, PM = Posttest Mean, DTM = Delayed Posttest Mean

As seen by Table 4, students in the experimental group scored 66.85 on the posttest on average, with a standard deviation of 14.27, whereas students in the control group scored 60.81 on average, with a standard deviation of 14.46. The experimental group's mean score on the delayed posttest was 61.85, with a standard deviation of 14.27, while the control group's mean score was 53.98, with a standard deviation of 13.89. Table 4 demonstrates that the retention rate of mathematics students in the experimental group—who were taught using both geometric models and lectures—was 92.52%, whereas the control group's rate was 88.77%.

HO_2: There is no significant difference between the mean retention scores of students taught mathematics using of lecture method blended with geometric models and lecture method.

Table 5
ANCOVA Summary Comparing Pretest and Delayed Posttest Mean Achievement Scores of Students Taught Mathematics Using Lecture Method Blended with Geometric Models and Lecture Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3421.298[a]	2	1710.649	8.600	.000
Intercept	47536.907	1	47536.907	238.994	.000
Pretest	3.469	1	3.469	.017	.895
Methods	3409.049	1	3409.049	17.139	.000
Error	43560.035	219	198.904		
Total	785230.000	222			
Corrected Total	46981.333	221			

Table 5 shows that the calculated f, with a p-value of 0.000, or less than 0.05, is 17.139 at the 0.05 level of significance. This indicates a substantial difference in the mean delayed posttest scores between students who learned mathematics through the lecture technique plus geometric models and those who learned it through the lecture method alone. The second null hypothesis is refuted as a result. When teaching mathematics, students who used both geometric models and the lecture approach showed significantly different mean retention scores than those who just used the lecture technique. The highest results were obtained by students who integrated their lectures on mathematics with geometric models.

Discussion

The study discovered that students who received their mathematics instruction via a lecture style combined with geometric models had considerably higher mean achievement scores than those who received their instruction via lecture alone. Probable explanation for this observation is that geometric models provide students with a visual aid that helps them better understand abstract mathematical concepts. This visual representation can make complex mathematical ideas more tangible and easier to grasp. Working with geometric models can enhance students' spatial skills, which are important for understanding geometry and other mathematical topics. Improved spatial skills can lead to better problem-solving abilities in mathematics. This could have transformed to higher achievement scores with students exposed to geometric models than students not exposed to models. This finding corroborates that of Huk and Banovic (2020) who found that incorporating geometric models into geometry instruction significantly improved students' understanding of geometric concepts and problem-solving skills. The study showed that students who used geometric models in their learning had higher test scores and demonstrated better retention of the material compared to those who did not use such models. Furthermore, a meta-analysis by Steenbergen-Hu and Cooper (2014) revealed that the use of visual models, particularly geometric ones, led to significant improvements in students' problem-solving and conceptual understanding in mathematics.

The study demonstrated once more a substantial difference in the mean retention scores between students who learned mathematics using lecture method plus geometric models and those who learned mathematics through lecture method alone. Students who were taught mathematics through lectures and combined it with geometric models performed best. This observation is predicated on the fact that geometric models make mathematics more engaging and interesting for students. The interactive nature of working with shapes and figures can increase motivation and curiosity, leading to higher levels of interest in the subject. Steenbergen and Cooper (2014) reported that learning through hands-on experiences, such as using geometric models, leads to better long-term retention of information. When students actively engage with geometric concepts in a visual and tactile manner, their retention of those concepts is enhanced. Another study by Boulware and Anderson (2017) explored the impact of dynamic geometric software on students' learning and retention in geometry. The researchers found that students who used dynamic geometric software showed greater improvement in their geometric knowledge and skills, and were able to retain the material better over time compared to those who used traditional methods of instruction.

Conclusion

The study concludes that incorporating geometric models in mathematics instruction has a positive impact on students' learning outcomes. Students who interacted with geometric models showed improved understanding, retention and overall achievement in mathematical concepts related to geometry. These findings highlight the importance of using hands-on and visual aids like geometric models to enhance the learning experience and foster deeper understanding of mathematical principles among students.

Recommendations

The study's conclusions led to the following recommendations:

1. Educators and curriculum designers should consider incorporating geometric models as a regular part of mathematics instruction to enhance students' learning experience.
2. Teachers play a crucial role in effective implementation of geometric models in the classroom. Therefore, it was recommended that educators receive training and professional development on how to effectively incorporate geometric models into their teaching practices.

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