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Effect of Puzzle Cooperative Learning Strategy and Lecture Instructional Approach on Students' Mathematics Achievement in Schools in Warri South Local Government Area, Delta State

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ABSTRACT

The effect of the lecture and puzzle cooperative learning method on the performance of students in mathematics with respect to changes in the instruction strategy was a topic of investigation in this study. The research design used was a quasi-experimental design consisting of a pretest, posttest and non-equivalent control group. The population of the study was approximately 4,000 students in the Warri South Local Government Area of Delta State. The mixed schools were separated by purposive sampling, and a sample size of 200 students was selected by simple random sampling. The study instrument was the Geometry Achievement Test (GAT), a test consisting of fifty multiple-choice queries and administered to collect data. The fifty items in the multiple-choice queries during the pretest and posttest were the same. Three experts in science education pilot-tested the tool, and the reliability coefficient was calculated using the Kuder Richardson Formula 21 (KR-21). The study followed two hypotheses and two research queries as a guide. The mean and standard deviation answered the research queries; t-test and ANCOVA at the 0.05 level significance was used to test the hypotheses. Based on the study outcomes, lecture methods and puzzle collaborative learning were influential to the extent that they exerted a significant effect on the mathematical ability of the students. Overall, it was found that the puzzle cooperative strategy proved efficient in enhancing the math ability of the students at different levels.

Keywords: Puzzle, Cooperative Learning Strategy, Lecture Approach, Mathematics Achievement

INTRODUCTION

A subfield of science called mathematics deals with the manipulation and analysis of numbers, including computations and problem-solving. Mathematics is a discipline that methodically unearths patterns, laws, principles, and theories to explain a variety of phenomena, according to Odogwu (2014). Because it provides tools for understanding science, engineering, technology, and economics, mathematics is essential to national development (Ijeh, 2014). According to Kravits (2013), mathematics is a skill that everyone should possess since it is fundamental to all facets of life and plays a significant role in public decision-making. Under the National Policy on Education (FRN, 2004), the federal government of Nigeria established mathematics as a core subject from primary to secondary school and a requirement for admission to Nigerian Universities Owing to the subject's significance to both human and national development. Therefore, it is not feasible to overstate the significance of possessing a sufficient understanding of and performing better in mathematics on external exams. For this reason, the national education policy (FRN, 2013) promoted better teaching and learning of science-related subjects particularly mathematics, as well as other sciences.

Despite recent advancements in teaching methods, the traditional lecture method is still used in nearly all Nigerian schools. The instructor upholds control over the instruction procedure, delivers the material orally to the entire class, and tries to emphasize factual knowledge (Ajaja and Eravwoke, 2011). According to Ajaja and Kpangban (2000), one of the main obstacles to the learning procedure is that students are passive, making it difficult to determine whether or not learning is occurring. Reports from the West African Senior Secondary

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Certificate Examination (WASSCE) from 2014 to 2023 revealed that less than 60% of the candidates received five credits with English language and mathematics, indicating that students' performance in mathematics is still below stakeholders' expectations. Every stakeholder in mathematics is generally concerned with raising student achievement and retention, which is why researchers have been looking for new approaches to teaching the subject. Therefore, this study will look at both the Puzzle cooperative learning strategy and the lecture instructional approach.

The Puzzle Cooperative Learning strategy is a way to set up classroom activities where students are divided into groups of four, five, or six and given assignments (subtopics) to complete as the group puts together the puzzle. Positive interdependence promotion, interaction, individual accountability, social skills, and group proceduring quality are the five fundamental components of this cooperative learning approach (Sagsoz 2017).

Aronson (1978) introduced the puzzle classroom cooperative technique. Students in a class are divided into small, diverse, inclusive groups of four, five, or six people, called the “home group. Each student is assigned a specific subtopic to study independently before moving on to an "expert group," where students review the material together before returning to their home group. The task is challenging in a large lecture classroom where the teacher is the only instructor. Every student, however, has the opportunity to contribute meaningfully to discussions and peer tutoring.

To determine the best way to teach mathematics in schools, regardless of a student’s sex, this study will specifically compare the effects of the Puzzle cooperative learning strategy and the lecture instructional approach on maths retention.

Problem Statement/Justification

Concern over the utmost efficient way to teach mathematics to students is growing as a result of topical progresses in teaching methods and the poor performance in mathematics in schools, especially on the West African Senior Secondary School Certificate Examinations (WASSCE). The question of the study is whether the use of the puzzle cooperative learning strategy and the lecture instructional approach will result in any discernible variances in the mathematical achievement of students in schools in Delta State's Warri South Local Government achievement of Area.

Objectives of the Study

This study's primary goal is to investigate how students' mathematical achievement in Delta State's Warri South Local Government Area is effected by the Puzzle cooperative learning strategy and the lecture instructional approach. The research would specifically look at:

- the effect of lecture instruction and the puzzle cooperative learning strategy on students' academic performance in Warri South LGA schools.
- the disparity between the mean achievement scores of students in Warri South LGA schools who were taught mathematics using the lecture instructional approach and the Puzzle cooperative learning strategy.

Research Questions

1. How will the Puzzle cooperative learning approach and the lecture instructional approach affect students' mathematical achievement?
2. How will the mean achievement scores of students taught mathematics using the Puzzle cooperative learning approach and the lecture approach differ from one another?

Hypotheses

H_1 There will be no discernible variance in the mean achievement scores of students taught Mathematics using the Puzzle cooperative learning strategy and those taught using the Lecture instructional approach.

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H_2 There will be no discernible variance in the mean achievement scores of students taught Mathematics using the Puzzle cooperative learning strategy and the lecture instructional approach.

LITERATURE REVIEW

Vygosky's (1978) social constructivism serves as the theoretical foundation for puzzle cooperative learning. According to Vygotsky's theory, social interaction and cultural experiences are the main factors that influence cognitive development. The theory states that letting kids interact with someone who knows more than they do can significantly improve their learning. This person could be anyone who has a deeper comprehension of the task or idea the child is attempting to learn. This theory emphasizes how important language use, culture, and society are in influencing how students learn. In contrast to the lecture perspective, which places the onus of teaching on the teacher while the students take on an unresponsive role, social constructivism places a strong emphasis on the importance of the learner being actively involved in the learning procedure. Based on Vygotsky's concept of the zone of proximal advancement, the cooperative learning theory emphasizes how learners are interdependent as they work together to complete tasks that may be difficult for them to complete on their own. Because students retain more information when working in groups, collaborative learning is essential for the development of critical thinking abilities. Peer-to-peer learning is encouraged by collaborative learning theory, which in turn stimulates more in-depth thinking in the classroom.

Students collaborate in groups of four to six to help one another comprehend academic material as part of Puzzle Cooperative Learning (Johnson, 2014). This teaching strategy encourages students of various skill levels to collaborate accomplish in small groups to a task (Akinbobola, 2006). Constructivist theory, according to Jean Piaget (1978), strongly emphasizes the duty of the teacher to value experience and connections in students' education. According to the theory, experiences shape meaning and construct knowledge. Assimilation and accommodation are two of the main abstractions in this theory that support the development of a person's new knowledge (Piaget, 1978). By combining experiences with preexisting ones, assimilation allows people to create new viewpoints, reconsider preconceived notions, and ultimately change their worldview.

Conversely, accommodation involves rethinking the world and new activities to make them fit into preconceived ideas. During cooperative learning, students work together in groups, fusing their social and intellectual skills to accomplish a shared goal. Usually, different groups are formed and each team member is given a portion of the material to learn. They are also in charge of the education of the other group members. Students put forth effort until the assignment is finished and everyone in the group has a firm understanding of the subject.

The cooperative learning approach emphasizes that to maximize each team member's academic performance, students must collaborate as a team, according to Hsiung Lou, Lin et al. Wang (2014). Each member of the team is essential to the team's success, and if the team fails as a whole, it could compromise the success of the group's achievement. Therefore, evaluating the team's performance necessitates evaluating both the contributions of each team member and the interactions among them.

In a cooperative learning setting, students actively pursue knowledge and information via mental engagement, using a variety of learning activities to improve their comprehension of a subject. According to developmental and cognitive theories, it is a learning environment that empowers students to take ownership of their education and actively engage in the learning procedure. It also promotes a collaborative classroom atmosphere. Johnson (2009). Organizing class activities into groups that represent the sex and ability distribution of the class is the aim of a cooperative learning environment. In this context, students actively seek knowledge and comprehension. It also enhances social and educational learning opportunities. The teacher is responsible for carefully selecting the group members who will oversee both individual and group learning while the students work together in groups to accomplish tasks. Each member's success is reliant on the group's success. In cooperative learning, the group's success comes before the individual's. The theoretical review states that puzzle cooperative strategy is a student centered learning approach. The use of learner-centered teaching strategies, such as the Puzzle cooperative strategy, was the focus of the empirical studies that were reviewed.

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To the best of the researcher's knowledge, however, no such studies have been conducted on how geometry concepts affect students' mathematics achievement at Delta State irrespective of their sexes by the lecture instructional approach and the puzzle cooperative learning strategy. The purpose of this study is to close this significant gap. This study will determine the effects of the lecture instructional approach and the puzzle cooperative strategy on students' mathematical achievement in Delta State schools in an effort to bridge the aforementioned gap.

METHODOLOGY

This study employed a quasi-experimental design with a pre-test, post-test, and non-equivalent control group.

The non-equivalent control design was chosen because intact classes served as the foundation for inclusion and the student selection procedure lacked randomization. The study's population consists of all Senior Secondary School II (SSII) students in Delta State's Warri South Local Government Area. The 18 public secondary schools have about 4,000 students enrolled. The Senior Secondary Two (SSII) students were used for the study because they had been taught topics in plane and solid geometry and were not preparing for any external exams.

The research sample consisted of approximately 200 Senior Secondary School students from four schools (four intact classes) in Delta State's Warri South Local Government Area. A simple random sampling technique known as balloting was used to select the four schools for the study. Simple random sampling (ballot) was chosen because each member of the population has an equal and known chance of being selected.

Additionally, it ensures that the elements chosen from the study population are representatives of the population from which the elements were drawn, as indicated by the statistics derived from the sample data. Two schools employed the lecture instructional approach, and two employed the puzzle cooperative learning strategy. The instructional approaches were dispersed at random among the four schools.

Data for the study was gathered using a tool called the Geometry Achievement Test (GAT). The GAT consists of fifty (50) multiple-choice objective test items drawn from previous geometry-related Senior Secondary Certificate Examinations (SSCE). The pre and post-tests was administered using the same tool. There were two parts to it: A and B. The demographics of the respondents are included in Section A, and the multiple-choice Geometry test items with options A via D are included in Section B. The post-test will use the same items, which will be rearranged. This was given to the lecture group and the puzzle cooperative learning group.

Face and content validity were used to validate this instrument. A three-person panel conducted the face validity of the Geometry Achievement Test. Copies of the first draft of the Geometry Achievement Test's multiple-choice items, the six-week instructional units, the research queries, and the hypotheses were provided to the validators by the researcher. Validators were asked to review the GAT's objective test items for word choice, test item appropriateness, and alignment with the six-week instructional units. The instrument for the study was used once the test items had been approved by the panel.

A table of specifications was used to verify the instrument's content validity, guaranteeing that the queries addressed every topic covered in the six-week instructional units. The SS II curriculum's guidelines, which follow Bloom's taxonomy served as a controller for generating the table of specifications.

The Kuder Richardson21 (K-R21) formula was used to determine the instrument's (GAT) reliability. Thirty students, ten females and twenty males who will not be involved in the primary study will be given the instrument. The Kuder Richardson21 Formula was applied to the test-retest results. Owing to its application to tests with items of variable difficulty that are scored dichotomously, the formula was deemed appropriate (Nworgu, 2015). The geometry achievement test had a reliability index of 0.76 and higher after test results were analyzed using the Kuder Richardson 21 formula. The instrument is dependable and appropriate for the study. This supports the suggestion made by Johnson and Christensen (2000) that a test's accuracy and precision are related to its reliability, and that a score of 0–70 or greater indicates that the test is accurate and

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reliable in measuring the traits it is intended to assess. The Kuder Richardson 21 formula is used because it is suitable for multiple-choice objective test items.

Four instructors, who served as the study's research assistants, would be assigned to each school to conduct the training. While the two instructors for the lecture instructional group received the training manual created by the researcher, two of the instructors received training in the cooperative instructional strategy known as Puzzle. The two instructors received two hours a day for two days of training in the Puzzle cooperative approach.

The roles that students played at each phase of the educational procedure were outlined in the manuals. When the researcher is satisfied that the trained instructors can successfully use the Puzzle cooperative instructional style to teach the chosen geometry abstractions, the training is concluded. The two groups were pretested with the GAT instrument two days before the commencement of the treatment and posttest six weeks after treatment.

Descriptive statistics (mean and standard deviation) were used to answer the research queries. ANCOVA and the t-test were used to determine whether the hypotheses were significant. The hypothesis will be tested at the significance level of 0.05.

Research Question One: How will the Puzzle cooperative learning approach and the lecture instructional approach affect students' mathematical achievement?

Table 1: Mean ($\bar{x}$) and Standard Deviation (SD) of Pretest and Posttest Achievement Scores of Students Taught Mathematics Using Puzzle Cooperative Learning Strategy (PCLS) and Lecture Instructional Approach (LIA)

Group	N	Pre-test		Posttest		Mean Gain
		Mean ($\bar{x}$)	SD	Mean ($\bar{x}$)	SD	
PCLS	108	24.26	8.95	58.33	11.63	34.07
LIA	92	22.50	7.84	43.54	10.14	21.04

Table 1 reflects how students performed in a pre-test and post-test relation on Puzzle Cooperative Learning Strategy (PCLS) and the Learning Instruction Approach (LIA) for the students regarding mathematics. In the PCLS group, the pre-test mean score was 24.26 and the standard deviation (SD) was 8.95, for the post-test mean score was 58.33 and the SD was 11.63. So the mean gain is 34.07. Conversely, for the LIA group, the pre-test mean score is 22.50 (SD = 7.84) and the post-test mean score is 43.54 (SD = 10.14), and the mean gain is 21.04. PCLS group mean gain suggests a stronger positive effect on achievement using the Puzzle Cooperative Learning Strategy when equated to the Lecture Instruction Approach.

Hypothesis One: There will be no discernible variance in the mean achievement scores of students taught mathematics using the Puzzle cooperative learning strategy and those taught using the lecture instructional approach.

Table 2: Paired Sample t-test Comparing the Pretest and Posttest Achievement Scores of Students Taught Mathematics Using Puzzle Cooperative Learning Strategy (PCLS) and Lecture Instructional Approach (LIA)

Group	N	Pretest		Posttest		df	t_{cal}	Sig.(2-tailed)	Remark
		M	SD	M	SD				
PCLS	108	24.26	8.95	58.33	11.63	107	36.822	0.000	Significant

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LIA	92	22.50	7.84	43.54	10.14	91	21.490	0.000	Significant

P < 0.05, HO_1 is rejected

The results in Table 2 present data from the tailed sample t-test of the pretest and posttest scores of students learning mathematics via cooperative learning puzzles (PCLS) and lectures (LIA). In the instance of the PCLS group, the t-calculated score of 36.822 with a .000 significance level shows strong variance between the pretest and posttest scores. The same applies for the LIA group, which had a t-calculated score of 21.490 with a .000 level of significance, thus proving that the variance between the pretest and posttest scores is strong. Since the significance level is below .05 for both groups, the null hypothesis (HO1) is rejected hence proving the strong effect of students learning via cooperative puzzles and students learning in lectures on the average achievement scores.

Research Question Two: The mean achievement scores of students taught mathematics using the lecture instructional approach and the Puzzle cooperative learning strategy will not differ significantly.

Table 3: Mean ($\bar{x}$) and Standard Deviation (SD) of Pretest and Posttest Achievement Scores of Students Taught Mathematics Using Puzzle Cooperative Learning Strategy (PCLS) and Lecture Instructional Approach (LIA)

Group	N	Pre-test		Posttest		Mean Gain	MGD
		Mean ($\bar{x}$)	SD	Mean ($\bar{x}$)	SD		
Pcls	108	24.26	8.95	58.33	11.63	34.07	13.03
LIA	92	22.50	7.84	43.54	10.14	21.04	

MGD = Mean Gain Difference

The Puzzle Cooperative Learning Strategy (PCLS) mean pre-test results were 24.26 (SD = 8.95) and post-test results were 58.33 (SD = 11.63) for a mean gain of 34.07. The LIA group with pre-test mean scores of 22.50 (SD = 7.84) and post-test mean scores of 43.54 (SD = 10.14) had a net mean gain of 21.04. The mean gain variance (MGD) is 34.07 for PCLS minus 21.04 for LIA and is 13.03. This comparison of gains from both groups indicates that PCLS has a much greater positive effect on student achievement scores than LIA.

Hypothesis Two: There will be no discernible variance in the mean achievement scores of students taught mathematics using the Puzzle cooperative learning strategy and the lecture instructional approach.

Table 4: ANCOVA Summary on Variance in the Mean Achievement Scores of Students Taught Mathematics Using Puzzle Cooperative Learning Strategy and Lecture Instructional

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	17980.742[a]	2	8990.371	105.908	.000
Intercept	27062.222	1	27062.222	318.796	.000
Pretest	7113.748	1	7113.748	83.801	.000
Method	9013.801	1	9013.801	106.184	.000
Error	16723.078	197	84.889		

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Total	565772.000	200			
Corrected Total	34703.820	199			

P(0.000) < 0.05, HO_2 is rejected

The achievement 2 scores of students in mathematics who were taught using the Puzzle Cooperative Learning Strategy (PCLS) as equated to those taught using the Lecture Instructional Approach (LIA) will be analysed in this section. Teaching approach (method) Type III Sum of Squares is 9013.801, F = 106.184, and p = 0.000. Since p < 0.05, the null hypothesis (HO2) is not supported. This means that students learning from cooperative 1 the Puzzle learning strategy outperform those learning from the lecture instructional approach.

DISCUSSION OF FINDING

The researcher revealed that both the Lecture Instructional Approach (LIA) and the Puzzle Cooperative Learning Strategy (PCLS) have a favourable effect on students' math proficiency. Students showed significant improvements in their post-test scores equated to their pre-test scores in both approaches, suggesting that both teaching methods are successful in increasing students' mathematical knowledge. Owing to its collaborative nature, PCLS actively engages students in the learning procedure via group and peer work. This method encourages students to take ownership of their education, which boosts their motivation, comprehension, and memory of mathematical ideas. Conversely, LIA improves student performance via structured instruction and content delivery, despite being more conventional and lecture-based. Lectures are beneficial because they are organized and fairly clear, which can aid students in comprehending complex mathematical ideas.

In conclusion, both PCLS and LIA improve student achievement, though the degree of each effect may vary based on the dynamics of the classroom and the subject matter being taught. This is consistent with Prieto-Saborit et al.'s findings. (2021) and Boadu and associates. (2024), who demonstrated the advantages of cooperative learning techniques like Puzzle. However, it contrasts the findings of Kumar et al. and Obeidat (2020), (2022), who also revealed that even though lectures aren't as interactive, they can still be useful for learning, particularly in certain circumstances. Additionally, the study revealed that students who were taught using the Puzzle Cooperative Learning Strategy (PCLS) outperformed those who were taught using the Lecture Instructional Approach (LIA). The outcome demonstrates the superiority of PCLS over more traditional methods like lectures in raising student achievement. PCLS students can take part in the learning procedure more actively when they receive training on how to collaborate with others and concentrate on student-centered learning. Students get the opportunity to collaborate and unravel problems in groups, which helps them comprehend the mathematical ideas more fully. In addition to enhancing academic achievement, this kind of interactive learning also fosters critical thinking and social skills. The latter result is in agreement with Prieto-Saborit et al. Drouet e t al. (2021), (2023), who found that puzzles were a useful cooperative learning tool that improved students' academic performance, especially in math. Nevertheless, the contradictory findings of Scalise et al. and Obeidat (2020), (2025) suggest that traditional lecture-based instruction may still be successful under certain circumstances, particularly if it is well thought out or combined with other techniques.

CONCLUSION

Both the Lecture Instructional Approach (LIA) and the Puzzle Cooperative Learning Strategy (PCLS) have been shown to have a positive effect on students' mathematical performance. However, the influence of PCLS was greater because it was more collaborative and interactive.

RECOMMENDATIONS

1. To improve students' math skills and engagement, teachers ought to employ more cooperative learning strategies, such as Puzzle.
2. Programmes for professional development should give educators the tools they need to implement cooperative learning techniques efficiently.

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