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Cooperative Learning Strategies and Senior Secondary Students' Performance in Mathematics in Oyigbo L.G.A of Rivers State, Nigeria

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Abstract
This study examined the impact of cooperative learning strategies on the performance of senior secondary school students in mathematics in Oyigbo L.G.A, Rivers State. The research was guided by three research questions and three null hypotheses. The study was conducted using a pre-test, post-test quasi-experimental research design. A three-stage simple random sampling method was employed to select a sample of 188 SS II students from a total population of 1,112 public SS II students across the seven public schools in Oyigbo L.G.A, Rivers State. The study utilized three intact classes for the investigation. The data collection instrument, developed by the researchers, was titled "Mathematics Achievement Test" (MAT) and consisted of 20 multiple-choice questions. A test-retest reliability method was employed to determine a reliability coefficient of 0.83. The students in the two EGs were taught the topics of quadratic equations by the formula method and word problems using the Jigsaw cooperative teaching strategy and the TPSS. The students in the control group were taught the same topics using the discussion teaching method. All three groups took a pretest and posttest using the MAT to measure their performance scores. The RQs were addressed using mean and StD, while the null hypotheses were tested using ANCOVA at a 0.05 sig. level. The findings of this study revealed that the use of cooperative learning strategies (Jigsaw and Think-Pair-Share) enhanced the performance of SS II students in mathematics. It was recommended that cooperative learning strategies be adopted as the most effective approach for teaching mathematics in S.S.S in Oyigbo L.G.A and other L.G.As of Rivers State. The study's results indicated that cooperative learning not only facilitated students' understanding of mathematics but also enhanced their performance.

Keywords: Cooperative strategy, Performance, jigsaw, think-pair-share, algebra, Mathematics

Introduction
Mathematics holds a fundamental place in the Nigerian educational system, spanning from primary to post-primary levels. Its prominent inclusion in school curricula stems from its critical contribution to advancements in science and technology. A solid grounding in mathematics is essential for a nation's progress. It serves as the cornerstone of intellectual growth in technologically advanced societies. According to Kolawole, mathematics serves as the foundation for making scientific predictions grounded in logical reasoning. It also provides the language through which scientific concepts and discoveries are conveyed to the practical world using mathematical expressions. Mathematics forms the foundation of science and technology, serving as a catalyst for national progress. Its dynamic nature extends its influence across various disciplines.

Oladosu posited that the primary aim of mathematics is to teach students how to think. Mathematics teachers are encouraged to move beyond merely transmitting knowledge, emphasizing instead the development of students' critical thinking abilities and equipping them to apply what they learn in tackling real-life challenges. For this to be achieved, the mathematics teacher should employ teaching approaches, methods, strategies or techniques that will enhance the performance of students in taught mathematics curriculum contents. A key question arises: which approach would be most effective and dependable in enhancing students' learning outcomes and performance in mathematics? It dawned on the researcher that cooperative learning strategy can help to improve students' performance in mathematics since the strategy involves learner-learner interaction and also teacher-learner interaction. Group work help students to better understand the taught mathematics concepts and stimulate their thinking processes.

The cooperative learning approach offers students a platform to interact with their peers, share innovative ideas, and convey knowledge through mathematical reasoning. The use of cooperative learning strategy limits the idea of teacher-centered instruction where the transfer of knowledge is strictly teacher-oriented. This encourages the individual students to be active, industrious and be self-confident in the group. This approach centers on problem-driven learning, where the process begins with a problem that needs solving. The problem is designed to require students to acquire new knowledge before they can effectively address it (Johnson *et al*., 2019) [11].

Mathematics teachers often rely on the conventional talk-and-chalk teaching method, which yields minimal improvement in students' performance. The use of traditional teaching method does not give room for interaction and sharing of ideas among students. According to Nwachukwu cooperative learning entails students collaborating in small groups to accomplish shared objectives. Wadata suggested that incorporating cooperative learning into mathematics instruction can be a powerful approach to enhance student engagement, foster collaboration, and deepen their understanding of mathematical concepts.

One way to incoporate cooperative learning in mathematics teaching is through the use of group problem-solving activities. In these activities, students work together to solve challenging mathematics problems, by sharing their strategies and approaches with each other. Through collaborative learning, students gain from one another's ideas and viewpoints, which helps them develop a more profound understanding of the mathematical concepts being studied. There are different types of cooperative learning strategies. It lies in the onus of the teacher to explore the features of the various cooperative strategies and settle for that which best fits the mathematics topic at hand. Rehu opined the various forms of cooperative strategies are the jigsaw, thin-pair-share, peer tutoring and collaborative project-based instruction.

Algebra is a branch of mathematics centered on using symbols and applying rules to manipulate them, enabling the solving of equations and the representation of relationships between various quantities. It serves as a foundational skill in mathematics and is essential for developing higher-level mathematical thinking and problem-solving abilities. This suggest why Gronmo asserted that algebra is the language of mathematics. In algebra, letters are used to represent variables, which can stand for unknown numbers or quantities that can vary. Algebra allows mathematicians to generalize relationships and patterns, making it a powerful tool for solving a wide range of mathematical problems. This may suggest why algebra is used in various fields such as economics, marketing, engineering, medicine, law, computer science, chemistry, physics, biology, and many more. The key concepts of algebra are expressions, equations, functions, inequalities.

Quadratic equations are a key topic within algebra. These equations are a specific type of algebraic equation where a variable is raised to the power of two. The general form of quadratic equation is $ax^2 + bx + c = 0$. Quadratic equations are used in various areas of mathematics and real-world applications (Edem & Awala). Thus, understanding how to solve quadratic equations is an essential skill in algebra and provides valuable tools for solving mathematical problems and analyzing relationships between variables.

Students often find algebra difficult due to its abstract nature. Another reason student have challenge in algebra is due to its procedural nature. Suwen carried out a study on difficult concepts in mathematics and found that students perform poorly in algebra due to its students' limited practice and lack of connections to everyday lives. Algebra has its own language with symbols, terms, and notations that may be unfamiliar to students. For students to understand algebra, the require to grasp fundamental concepts such as variables equations, functions and graphs. Lack of conceptual understanding of algebraic concepts makes students to struggle with it. If students struggle to build a strong foundation in algebraic concepts, it can hinder their ability to solve more complex problems. Fure (2022) argued that employing a cooperative learning strategy in algebra instruction can significantly improve students' performance. Therefore, this study aims to examine the effectiveness of using cooperative learning to teach algebra, a branch of mathematics.

Statement of the Problem

The performance of students in mathematics, as shown in exam results, has raised ongoing concerns among all education stakeholders. The low performance of students in mathematics may be a significant factor hindering the achievement of many educational and societal objectives. The way mathematics teacher deliver mathematics curriculum contents to students is another major concern among the stakeholders of education. Mathematics teachers as observed by the researcher has wholeheartedly embraced the use of traditional teaching method which render students passive during classroom lesson delivery to teach. Traditional teaching method is teacher-centred, passive and encourages memorization of facts.

There are various innovative instructional strategies which can be employed so that students can interact amongst themselves, collaborate and learn freely without tension. The cooperative learning strategy comes to mind since it is innovative and student-centred. The researcher started to question the underlying causes of students' poor performance in mathematics. Could it be the teacher-centered teaching approach which teachers employ to teach mathematical concepts? It is therefore, desirable to investigate other alternative strategies over the existing traditional teaching methods of teaching. To tackle this issue, the researcher chose to conduct a study to examine the impact of

cooperative instructional strategies on students' performance in mathematics.

Aim and Objectives of the study

The aim of the study was to investigate the effect of various cooperative learning strategies on S.S.S students' performance in mathematics in Rivers State. Specifically, the objectives of the study were to:

1. Ascertain whether there is any difference between the mean score performance of students taught mathematics using JSCS and those taught using think-pair-share cooperative learning strategy.
2. Determine if there is a difference between the mean score performance of students taught mathematics using JSCS and those taught using discussion teaching method.
3. Find out whether there is any difference between the mean score performance of students taught mathematics using think-pair-share cooperative learning strategy and those taught using discussion teaching method.

Research Questions

1. What is the difference between the mean score performance of students taught mathematics using JSCS and those taught using think-pair-share cooperative learning strategy?
2. What is the difference between the mean score performance of students taught mathematics using JSCS and those taught using discussion teaching method?
3. What is the difference between the mean score performance of students taught mathematics using think-pair-share cooperative learning strategy and those taught using discussion teaching method?

Hypotheses

The null hypotheses posed below were tested at 0.05 significant level.

H_{O1}: There is no significant difference between the mean score performance of students taught mathematics using JSCS and those taught using think-pair-share cooperative learning strategy.

H_{O2}: There is no significant difference between the mean score performance of students taught mathematics using JSCS and those taught using discussion teaching method.

H_{O3}: There is no significant difference between the mean score performance of students taught mathematics using think-pair-share cooperative learning strategy and those taught using discussion teaching method.

Research Design

The study utilized a quasi-experimental research design, specifically a pretest-posttest non-equivalent, non-randomized approach. Intact classes were used, with three groups (2 experimental and 1 control) being formed. The structure of the quasi-experimental design is shown in Table 1.

Table 1: Outline of the quasi experimental design

Group	Pre-test	Treatment	Post-test
E_1	O_1	X_{JSC}	O_2
E_2	O_1	X_{TPS}	O_2
C	O_1	C_{DTM}	O_2

Where;
E_1 = Experimental Group 1
E_2 = Experimental Group 2
C = Control Group
O_1 = Pretest
O_2 = Posttest
X_{JSC} = Taught using Jig-Saw Cooperative
X_{TPS} = Taught using Think-Pair-Share
X_{DTM} = Taught using Discussion Teaching Method

Population of the Study

The study's population included all 1,112 SS2 students from the 7 public government S.S.S in Oyigbo L.G.A, Rivers State, Nigeria. This population consists of eight hundred and ten (810) female students and three hundred and two (302) male students.

Sample and Sampling Technique

The sample for this study was 188 SS2 students. The sample was drawn from the population. The study used a sample of all students from three intact classes. The study involved three schools that were randomly selected, and a three-stage simple random sampling technique was employed to choose three intact classes from these schools. The process started with the random selection of the schools. In the second stage, two experimental schools and one control school were randomly chosen. The final stage involved randomly selecting one intact class from each of the three selected schools. The students in the intact classes were not randomized.

Instrument for Data Collection

The data for the study was collected using an instrument called the "Mathematics Achievement Test" (MAT), which was developed by the researchers. The MAT consisted of 20 multiple-choice questions and was divided into two sections: A and B. Section A gathered the bio-data of the sample students, while Section B included 20 multiple-choice questions focused on solving quadratic equations using the quadratic formula, as well as word problems that led to quadratic equations. Each question in the MAT had four options, labeled A to D, with three distractors (incorrect answers) and one correct answer. For each correct response, students received 5 marks, while incorrect answers earned zero marks. The MAT instructions instructed students to circle only 1 correct answer for each question. The total possible score for the MAT was 100%. A table of specifications (Table 2) was created based on Bloom's revised taxonomy of educational cognitive levels. The researchers also developed a marking guide to assist in the grading and scoring of the MAT.

Table 2: Table of Specification for Mathematics Achievement Test (MAT)

S/N	Topic	Remembering (25%)	Understanding (20%)	Applying (15%)	Analyzing (15%)	Evaluation (25%)	Total (100%)
1.	Derive the Quadratic Formula (20%)	1	1	1	1	1	4
2.	Use of Quadratic Formula to Solve Quadratic Equations (24%)	1	1	1	1	2	6
3.	Express Word Problems as Quadratic Equations (28%)	1	1	1	1	1	5
4.	Solve Word Problems leading to Quadratic Equations (28%)	2	1	1		1	5
	Total (100%)	**5**	**4**	**3**	**3**	**5**	**20**

Validation of the Instrument

Two Mathematics education experts assessed the MAT for face and content validity. The researchers incorporated their feedback to refine the instrument prior to administering it to the sample.

Reliability of the Instrument

The reliability of the MAT was determined using the test-retest method. The instrument was administered to 20 SS 2 students, who were not part of the main study, to calculate the reliability coefficient. To achieve this, the MAT was initially administered to the twenty students without prior instruction. After two weeks, the same test items were rearranged and given again to the same group of students. The results from the first and second tests were then analyzed using PPMC coefficient to determine the correlation. A reliability coefficient of 0.83 was established for MAT.

Method of Data Collection

The researchers developed the lesson plans used to teach the 3 groups (2 experimental and 1 control). Lesson plans were prepared on quadratic formula and word problems leading to quadratic equation. The researchers prepared one lesson plan for each of the three groups. The lesson for experimental group one (EG1) utilized the jigsaw cooperative learning strategy, while the lesson for experimental group two (EG2) applied the TPSS. The lesson for the control group (CG) followed the discussion-based teaching method.

The regular mathematics teachers of the sample students served as research assistants for the teaching process. These teachers were trained by the researchers over two consecutive days on how to implement the lessons using the lesson plans developed by the researchers. The teachers were closely supervised during the teaching sessions to ensure that the lessons followed the prescribed procedures. The lesson plans served as the primary guide for teaching both the experimental and control groups. The students were not informed about the experiment to prevent any behavior that might distort the results.

A pretest of the MAT was initially given to the two EGs and the CG, followed by the teaching of the topics for two weeks. Subsequently, a post-test containing restructured MAT items was given to all three groups. The students' responses from both the pre-test and post-test were gathered, evaluated, scored as percentages, and statistically analyzed to facilitate meaningful interpretation and discussion.

Method of Data Analysis

The research questions were addressed using mean and StD, while the null hypotheses were tested with ANCOVA at a 0.05 sig. level.

Results

RQ 1: What is the difference between the mean score performance of students taught mathematics using JSCS and those taught using think-pair-share cooperative learning strategy?

Table 3: Mean and StD on performance of students taught mathematics with jigsaw cooperative strategy and think-pair-share cooperative strategy

Group	N	Pretest		Posttest		Performance (Gain)	
		Mean	StD	Mean	StD	Mean	StD
JSCS	63	37.52	11.27	59.84	13.62	22.32	9.58
TPSS	60	29.34	10.06	62.09	12.40	32.75	8.31

JSCS = Jig Saw Cooperative Strategy
TPSS = Think-Pair-Share Strategy

Table 3 showed the mean and StD on performance of students that were taught mathematics with jigsaw cooperative strategy and think-pair-share cooperative strategy. From table 3, it is shown that the students who were taught with JSCS in the EG1 had a mean gain of 22.32, StD = 9.58 and those taught with TPSS in EG2 had a performance mean gain of 32.75, StD = 8.31. The data analysis in table 3 showed that the students that were taught mathematics with think-pair-share cooperative strategy performed better than those that were taught with jigsaw cooperative strategy.

RQ 2: What is the difference between the mean score performance of students taught mathematics using JSCS and those taught using discussion teaching method?

Table 4: Mean and StD on performance of students taught mathematics with JSCS and discussion teaching method

Group	N	Pretest		Posttest		Performance (Gain)	
		Mean	StD	Mean	StD	Mean	StD
JSCS	63	37.52	11.27	59.84	13.62	22.32	9.58
DTM	65	35.41	12.83	47.91	11.65	12.50	8.54

JSCS = Jig Saw Cooperative Strategy
DTM = Discussion Teaching Method

Table 4 showed the mean and StD on performance of students that were taught mathematics with jigsaw cooperative strategy and discussion teaching method From table 4, it is evident that the students who were taught with jigsaw cooperative strategy in the EG1 had a mean gain of 22.32, StD = 9.58 and those taught with discussion teaching method in CG had a performance mean gain of 12.50, StD = 8.54. The data analysis in table 4 showed that the students that were taught mathematics with jigsaw cooperative strategy performed better than those that were taught with discussion teaching method.

RQ 3: What is the difference between the mean score performance of students taught mathematics using TPSS and those taught using discussion teaching method?

Table 5: Mean and StD on performance of students taught mathematics with think-pair-share strategy and discussion teaching method

Group	N	Pretest		Posttest		Performance (Gain)	
		Mean	StD	Mean	StD	Mean	StD
TPSS	60	29.34	10.06	62.09	12.40	32.75	8.31
DTM	65	35.41	12.83	47.91	11.65	12.50	8.54

TPSS = Think-Pair-Share Strategy
DTM = Discussion Teaching Method

Table 5 showed the mean and StD on performance of students that were taught mathematics with think-pair-share cooperative strategy and discussion teaching method. From table 5, it is evident that the students who were taught with think-pair-share cooperative strategy in the EG2 had a mean gain of 32.75, StD = 8.31 and those taught with discussion teaching method in CG had a performance mean gain of 12.50, StD = 8.54. The data analysis in table 5 showed that the students that were taught mathematics with TPSS performed better than those that were taught with DTM.

H_{O1}: There is no significant difference between the mean score performance of students taught mathematics using JSCS and those taught using TPSS.

Table 6: Summary of ANCOVA on the difference in the performance of students taught mathematics using JSCS and those taught using TPSS

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	η^2
Corrected Model	2388.566	2	1190.283	8.212	.000	.231
Intercept	11310.028	1	11310.028	78.027	.000	.410
Group	2263.888	1	2263.888	15.618	.086	.118
Pretest	83.691	1	83.691	.577	.449	.058
Error	16959.225	120	144.951			
Total	402975.000	123				
Corrected Total	19339.792	122				

Table 6 showed the presentation of the summary of ANCOVA on the difference between the performance of students taught mathematics using jigsaw cooperative strategy and think-pair-share strategy. From the result, it was revealed that no significant difference exists between the performance mean score of students taught mathematics with jigsaw cooperative strategy and think-pair-share strategy (F_1, 120=15.618, p=.086; p>.05, η^2 =.118). H_{O1} was retained at a probability level of 0.05 since p-value > 0.05.

H_{O2}: There is no significant difference between the mean score performance of students taught mathematics using JSCS and those taught using DTM.

Table 7: Summary of ANCOVA on the difference in the performance of students taught mathematics using JSCS and those taught using DTM

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	η^2
Corrected Model	3605.358	2	1802.679	23.250	.000	.425
Intercept	1683.387	1	1683.387	21.712	.000	.256
Group	3310.683	1	3310.683	42.700	.000	.069
Pretest	360.587	1	360.587	4.651	.035	.404
Error	4884.581	125	77.533			
Total	353520.000	128				
Corrected Total	8489.939	127				

Table 7 showed the presentation of the summary of ANCOVA on the difference between the performance of students taught mathematics using jigsaw cooperative learning strategy and those taught using discussion teaching method. From the result, it was revealed that a significant difference exists between the performance mean score of students taught mathematics using JSCS and those taught using discussion teaching method (F_1, 125=42.700, p=.000; p<.05, η^2 =.069). H_{O2} was rejected at a probability level of 0.05 since p-value < 0.05.

H_{O3}: There is no significant difference between the mean score performance of students taught mathematics using TPSS and those taught using DTM.

Table 8: Summary of ANCOVA on the difference in the performance of students taught mathematics using TPSS and those taught using DTM

Source	SS	Df	MS	F	Sig.	η^2
Corrected Model	5203.062	2	2601.531	57.371	.000	.624
Intercept	5122.713	1	5122.713	112.969	.000	.621
Group	1045.017	1	1045.017	23.045	.000	.250
Pretest	3568.845	1	3568.845	78.702	.000	.533
Error	3128.882	122	45.346			
Total	280900.000	125				
Corrected Total	8331.944	124				

The result from Table 8 showed the summary of ANCOVA on the difference between the mean score performance of students taught mathematics using TPSS and those taught using discussion teaching method. From the result, it was revealed that a significant difference exists between the performance mean score of students taught mathematics using think-pair-share strategy and those taught using discussion teaching method (F_1, 122=23.045, p=.000; p<.05, η^2 =.250). H_{O3} was rejected at a probability level of 0.05 since p-value < 0.05.

Discussion of Findings

The results of the study revealed that students in EG2, who were taught mathematics using the TPSS, outperformed those in EG1, who were taught using the JSCS. This was reflected in the mean performance scores, where students in EG2, taught with the TPSS, had higher scores compared to those in EG1, who were taught using the JSCS. When the data was analyzed statistically, the results indicated that there was no significant difference between the mean performance scores of the two groups. This finding aligns with the results of Daiko *et al*. (2023) [7], whose study showed that students taught using the TPSS outperformed those taught the same topic with the JSCS, with no significant difference when analyzed statistically.

This study's findings also support the results of Oni (2021) [18], which indicated that students taught mathematics using a cooperative strategy in the EG performed better than those in the CG who were not exposed to the strategy. Additionally, a significant difference in mathematical achievement was observed between students who experienced the cooperative strategy and those taught using the conventional method.

The findings also indicated that students taught mathematics (quadratic equations) using the JSCS in experimental group one outperformed those taught the same topic using the discussion method. Further statistical analysis revealed a significant difference in their performance mean scores. This result aligns with the findings of Kwame and Samuel (2020), whose study showed that students taught mathematics using a cooperative teaching strategy performed better than those taught with traditional methods, with a statistically significant difference. This finding also supports the results of Abdullahi *et al*. (2021) [1], which revealed that students taught mathematics using a cooperative learning strategy performed better than those taught with the discussion method, with no statistically significant difference in the performance between the two groups. In line with this study's findings, Bomanyet (2020) [6] found that students taught statistics using a collaborative instructional strategy had better performance and retention compared to those taught using the traditional teaching method. The results also indicated a significant difference in the performance of students taught using the collaborative instructional strategy compared to those taught with the traditional teaching method.

Another study supporting these findings is the work of Fasasi and Istifanus which showed that students taught algebra using the jigsaw cooperative strategy outperformed those taught the same topic with the discussion method, with a statistically significant difference in their performance.

The results also revealed that students taught mathematics using the TPSS in EG1 performed better than those in the CG who were taught with the discussion method. A significant difference was found between the mean performance scores of the two groups. This finding is consistent with the results of Omeodu and Fredrick (2023) [17], who found that students in the EG, taught quadratic equations using the TPSS, performed better than those in the CG, who were taught the same topic using the expository teaching method. A significant difference was observed between the performance of students in the EG and those in the CG. In accordance with this result, Galarza (2022) [9] found that students taught algebraic equations using the cooperative learning strategy achieved higher content performance than those taught the same topic using the lecture method.

Conclusion

Based on the study's findings, it was concluded that the use of cooperative learning strategies (jigsaw and think-pair-share) enhanced students' performance in algebra more than the discussion teaching method, with a statistically significant difference. The TPSS improved students' performance in algebra than the JSCS though with no statistically significant difference

Recommendations

Based on the findings, the following recommendations were proposed:

1. The TPSS should be used as a method for teaching mathematics to students.
2. Mathematics teachers should be urged to incorporate the TPSS in their teaching practices.
3. Given that both cooperative learning strategies significantly enhanced students' academic performance in algebra, either strategy can be effectively used to teach mathematics lessons.

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