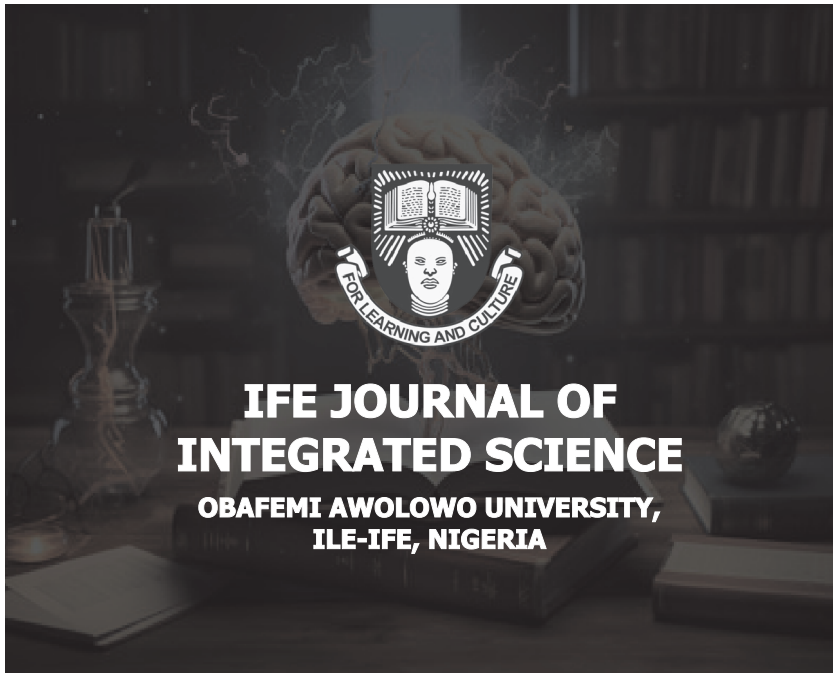

IJIS

Journal of the Institute of Education
Obafemi Awolowo University, Ile-Ife, Nigeria

ISSN: 3043-6400

Vol. 2, No. 1, 2025

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EFFECT OF JIGSAW COOPERATIVE INSTRUCTIONAL STRATEGY ON SECONDARY SCHOOL STUDENTS' ACQUISITION AND RETENTION OF MATHEMATICS PROCESS SKILLS

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Abstract
The study determined the effect of Jigsaw Cooperative Instructional Strategy on students' acquisition and retention of Mathematics process skills in Senior Secondary Schools in Delta State, Nigeria. Two research questions were raised, hypothesized and tested at 0.05 alpha level of significance. Quasi-experimental non-equivalent pretest, posttest, non- randomized control group design was used. The population of the study was 1874 students. The sample for study consisted of fifty eight students, the experimental group consists of 31 students and the control group comprised 27 students. Data collected through Geometry

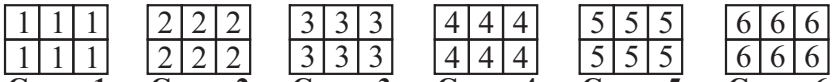
Achievement Test (GAT) were analyzed and interpreted using: mean, standard deviation and Analysis of Covariance (ANCOVA). The findings of the study revealed that the strategy helped students acquire acquisition of Mathematics process skills in Geometry among students. Therefore, based on the finding of the study, the following recommendations were made: Mathematics teachers should be encouraged to teach Geometry Jigsaw Cooperative Instructional Strategy to enhance students' active participation during lessons for better understanding and that students should be given the opportunity to develop various Mathematics process skills through the use of the strategy.
Keywords: Jigsaw Cooperative Instructional Strategy, Acquisition, Retention and Mathematics Process Skills

Introduction

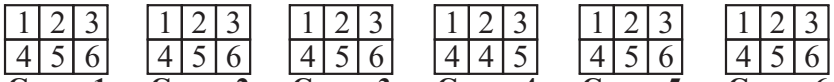
Cooperative learning is an educational strategy in which two or more students collaborate to complete a common task (Siegel, 2005). In this setting, students achieve their learning objectives by assisting one another within small social groups that comprise individuals with varying skill levels with each member assigned a distinct task. They engage in diverse learning activities to enhance their understanding of the subject matter. Because cooperative learning fosters active engagement, it allows learners to interact with their peers, stimulating their intrinsic motivation to learn.

The class is subdivided into initial groups known as the "home" groups where each learner is given a task to carry out. From the formed "home" groups, students are further regroup to constitute the "expert" groups. The "expert" groups are formed by students with same task from the "home" groups to work to together to discuss given task and refer to materials especially their textbook and make common decision regarding the assigned task. After mastery the task in their "expert" groups then they go back to their initial "home" groups to present their finding to the other group members.

Home Groups Formation



Expert Groups Formation



***Teacher's Role in* Jigsaw cooperative instructional strategy**

The teacher plays a crucial role in shaping the classroom environment, helping students build confidence, engage actively, communicate, collaborate, and respect each other. The teacher must participate in the knowledge-building process and take on roles as an observer, mediator, adviser, and tutor, guiding students and addressing challenges. According to Aronson (2000), these roles can be summarized as: 1. The teacher forms Jigsaw groups of 4 to 6 students, ensuring diversity in gender, ethnicity, and ability, 2. Each group selects a mature student as leader, 3. The lesson is divided into 4 to 6 segments, 4. Each student receives a segment to learn, 5.Students take time to write down and familiarize themselves with their segment, 6. Students join "expert groups" with peers assigned the same task to discuss and refer to textbooks, 7. Students return to their jigsaw " home groups", 8. Each student presents their task to the group, 9. The teacher observes and intervenes if any group encounters difficulties, and lastly, 10. A quiz is administered on the material learned, to be graded by the teacher.

Students' Responsibility in Jigsaw cooperative instructional strategy Students should follow these guidelines in the classroom:

1. Work in mixed-ability groups of 4-6,
2. Focus on a shared goal of problem-solving,
3. Collaborate as a team,
4. Make decisions by consensus,

5. Feel free to ask and answer questions within the team,
6. Listen to each other,
7. Teach and encourage one another,
8. Respect and trust one another,
9. Aim for the team's progress and success, and
10. Strive to maximize team points.

The Mathematics classroom suppose to equips secondary school students with essential skills through collaboration through activities such as observing objects, analyzing figures and shapes, participating in laboratory experiences, and working with texts and graphs. Opateye (2012) highlighted that these skills promote positive scientific attitudes and dispositions, fostering curiosity, imagination, and enthusiasm for mathematical concepts. Furthermore, Sevilay (2011) emphasized that mastering these skills enables deeper conceptual understanding and prepares students for future knowledge acquisition. Skills learned through inquiry do not only improve content comprehension but also enhance critical thinking, creative assessment, and decision-making.

There is always a relationship between a given Mathematics problem, the associated process skills and the inherent solution to the problem:

Mathematics Problem ⟶ Process Skills ⟶ Solution to Problem

Accordingly, when students do mathematical problems they must problem solve, communicate, reason, reflect, connect and decide what tools to use. These processes help the student develop knowledge and understanding of concepts, and these skills are required in all the strands in every level of our secondary school education sysyem.

The poor academic achievement obtained yearly at West African Examination Council (WAEC) results may imply that students continually have learning difficulties in Mathematics. The evidences from these results seem to suggest that Mathematics classrooms may not be providing students with adequate content and enabling environment sufficient to enhance good academic achievement in secondary school Mathematics. From the West African Examination Council (WAEC) Chief

Examiner's Report for some decades, Geometry seems to top the list of topics in Mathematics predominately mentioned among others where candidates continually have difficulties and that majority of candidates who sat for the examinations avoid completely questions in Geometry and even the few that attempt questions in Geometry performed poorly. These are indications that there may be challenges in the teaching and learning of Geometry in Mathematics. Analysis of previous WACE examination question papers spanning several years reveal that approximately 35 percent of questions annually, in both objectives and essays pertain to Geometry and related topics. Given this recurring trend in examinations, it becomes evident that students require a strong and comprehensive grasp of Geometry to excel in Mathematics as a subject before examinations are taken.

The most commonly used teaching method from literature in secondary school Mathematics is the traditional teacher-centered lecture approach, often referred to as "talk and chalk." In this method, teachers present examples on the board while students passively copy into notebooks, leading to poor understanding of mathematical concepts and rote memorization becomes the way out during examinations. Confirming this, Omoifo, (2012) observed that the lecture method leads to rote memorization and majority of students finds it difficult to understand mathematical ideas and concepts that way. Thus, the lecture method alone cannot help students achieve what it entails to learn and understand Geometry content.

To address the inadequacy of the lecture method in secondary school Mathematics education, it is vital to explore alternative approaches that can improve student performance and align with national goals. The search for methods that are effective and result oriented in Mathematics is crucial and should be continuous due to the dynamics of the subject. The use of wrong methods and non-usage of appropriate instructional techniques by the teacher leads to impaired understanding of mathematical concepts which is a factor that can results in students' poor performance in our standardized examination (Makinde, 2012). In addition, Agbarogi, Eraikhuemen and Idehen (2023), noted, that in recent years several researches have been done on different

teaching strategies, with their associated findings and suggestions which they deem appropriate for the teaching and learning of Mathematics enhancement; but these findings and suggestions are hardly used by teachers.

The National Policy on Education clearly states in the senior secondary Mathematics curriculum that the cardinal aims and objectives of secondary school Mathematics education is to prepare the students to:

1. Acquire Mathematical literacy necessary to function in an information age.
2. Cultivate the understanding and application of Mathematics skills and concepts necessary to thrive in the ever changing technological world.
3. Develop the essential elements of problem solving, communication, reasoning and connection within their study of Mathematics
4. Take advantage of the numerous career opportunities provided by Mathematics
5. Become prepared for further studies in Mathematics and other related fields.

The aims and objectives numbers 2 and 3 among the five listed as stipulated in the present curriculum is to help in achieving numbers 1, 4 and 5; and these aims and objectives numbers 2 and 3 can be summarised as the Mathematics process skills (MPS). These include: Problem solving, Communicating, Reasoning and proving, Reflecting, Connecting, Representing and Computational strategies which all students must understand and acquire at the secondary school level to be able to apply Mathematics knowledge to the real life after finishing from the secondary school. (National Policy on Education, 2013).Teachers are therefore encouraged to use different strategies to teach lessons and students' active rather than just the lecture method alone.

Acquisition and retention of are the real essence of teaching and learning in schools. Acquisition seeks to know how much of what the teacher present to learners that they actually understood and acquired while retention deals with how much of what has been learnt has been properly encored in their brain

through various experiences for future use. These two issues are necessary for examinations. It is the academic performance during the examination that determines the extent of what the students truly learnt and understood from the lesson. Hence, the focus of the study is to find ways of acquiring the Mathematics process skills that can aid the retention of content of Geometry for better achievement.

The researchers had found some qualities in JCIS which is purely student-centered activity based learning strategy. The effectiveness of using JCIS in teaching students to understand abstract mathematical ideas and concepts for better performance cannot be ignored in the world where application of mathematical concepts and ideas are needful. And since students are to be involved in the teaching and learning process themselves; the acquisition and retention of the MPS will be faster. There is also the possibility that what students teach others, they will remember and recall later during examination thus leading to better performance. This strategy have been found efficient in bringing positive change in some school subjects like Basic Science, Agricultural Science, Biology, Chemistry and Physics, rather than Mathematics (Al-Qaisi, 2015) noted.

Statement of the Problem

Research indicates that effective Mathematics teaching is hindered by several factors, including student attitudes, a shortage of qualified Mathematics teachers, inadequate foundational skills, the lack of dedicated mathematics laboratories, insufficient instructional materials, and ineffective teaching methods. According to Fatade, Mogari, and Abayomi (2013), much of the failure in school mathematics is linked to traditional teaching approaches that do not cater to how most students learn. They emphasize that these outdated methods prevent students from actively constructing their own mathematical understanding.

Purpose of the Study

The general objective of the study was to determine the effect of Jigsaw Cooperative Instructional Strategy on secondary school students' acquisition and retention of Mathematics Skills in Warri South local government area of Delta State.

Therefore the specific objectives are to:

a. determine the effect of jigsaw cooperative instructional strategy on senior secondary school students' achievement in the acquisition of Mathematics Process Skill.
b. examine the effect of jigsaw cooperative instructional strategy on senior secondary school students' retention in the acquisition of Mathematics Process Skill.

Methodology

Quasi-experimental research design was adopted for the study, using the non-equivalent pretest, posttest, control group design. Intact classes were used as experimental and control groups as there was no randomization of samples. The experimental group was exposed to Jigsaw cooperative instructional strategy while the control group was taught with the Lecture Method of teaching. The population of the study was 1874 senior secondary schools class two (SS II) students. For homogeneity, all the schools chosen have almost the same facilities regardless of where they are situated in the area of the target population.

The sample of 58 students were chosen from two senior secondary schools class two (SS II) for the study. Purposive sampling technique was used due to number of students, availability of space and teachers readiness among other factors such as number of students in a class and closeness of schools to each other. One intact class each in two schools were used. Experimental group received treatment on Jigsaw cooperative instructional strategy while the control group was taught using the Lecture Method of instruction.

The instrument for data collection was Geometry Achievement Test (GAT) developed by the researchers. The GAT items constructed were based on four topics in Geometry, namely:

chord property, circle theorems, trigonometry and bearing as contained in the senior secondary education curriculum Mathematics for class two (SS II). The items contain 30 multiple choice objective test questions with four (4) option given (A to D) from which the students are to choose the right answer; to test students cognitive domain of knowledge, comprehension, application and higher order. The instrument was made of two sections A and B. Section A covered student's bio data involving Sex (male and female) and name of school while section B was made up of the test items. The GAT items were pilot tested in a school that was not part of the main study in Warri South LGA of Delta State.

To ensure content validity of the GAT a table of specification was made, the researchers used three experienced Mathematics educationist to scrutinize the GAT, who retained, modified and deleted where necessary questions they found inappropriate. Their corrections were effected for the final copy of the instrument.

The reliability of the GAT was determined using Kuder-Richardson formula 21 Statistics. One intact class of fifty seven (57) students in a public senior secondary schools class two (SS II) in Warri South, Delta State not part of the sample for the study was used. Kuder- Richardson 21 formula was used for establishment of internal consistency of multiple choice items of the achievement test. The scores obtained were used to determine the coefficient of internal consistency: thus the reliability of the instrument was found to be 0.78; this was high enough for the instrument to be used for the study.

The data collected from students' Pretest, Posttest and Retention scores using Geometry Achievement Test (GAT) were analyzed and interpreted using descriptive statistics: mean and standard deviation to answer the research questions 1 and 2 while inferential statistics was used to test hypotheses for significant differences; the Analysis of Covariance (ANCOVA) was used to test the two hypotheses at 0.05 alpha level of significance.

Hypothesis

H_o1: There is no significant effect of jigsaw cooperative instructional strategy on senior secondary school students' achievement in the acquisition of Mathematics process skills

H_o2: There is no significant effect of jigsaw cooperative instructional strategy on senior secondary school students' retention in the acquisition of Mathematics process skills.

Table 1: Mean and Standard Deviation of Students' Pretest and Posttest in Jigsaw Cooperative and Lecture Instructional Strategies in Acquisition and retention of Mathematics Process Skills.

Groups	N	Pretest Mean	SD	Posttest Mean	SD	Mean Gain
Jigsaw Cooperative Strategy	31	6.45	2.669	10.52	2.827	4.07
Lecture Strategy	27	3.96	1.850	7.59	2.591	3.63
Total	58					

The data in Table 1 shows students in the Jigsaw cooperative got a mean score of 6.45 and a standard deviation of 2.669 in pretest, a mean score of 10.52 and a standard deviation 2.827 at posttest, making a pretest-posttest mean gain of 4.07. The Lecture strategy participants got a mean score of 3.96 at pretest and a standard deviation of 1.850, a mean score of 7.59 and a standard deviation of 2.591 at posttest, making a pretest-posttest mean gain of 3.63. The results further indicated that the Jigsaw cooperative group had higher mean score gain of 4.07 while Lecture group which had a mean gain of 3.63. To conclude on whether or not the observed pretest and posttest mean differences are significant, ANCOVA statistics was utilized to test hypothesis one as presented in Table 2.

Table 2: Analysis of Covariance (ANCOVA) of Students' Acquisition of Mathematics process skills in Geometry at Posttest

Dependent Variable: Posttestconexp

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	126.805[a]	2	63.402	8.489	.001	.236
Intercept	675.325	1	675.325	90.416	.000	.622
Pretestconexp	3.462	1	3.462	.463	.499	.008
Strategies	78.673	1	78.673	10.533	.002	.161
Error	410.799	55	7.469			
Total	5399.000	58				
Corrected Total	537.603	57				

a. R Squared = .236 (Adjusted R Squared = .208)

Table 4 shows the ANCOVA analysis of students' acquisition of Mathematics process skills in Jigsaw cooperative and Lecture Instructional Strategies at pretest and posttest. The result indicates that $F_{(1, 55)} = 10.533$, $p = .00 < 0.05$ which is significant at 0.05 alpha level. This means that there is a significant difference in the mean scores of students' acquisition of Mathematics process skills taught Geometry using Jigsaw cooperative and Lecture instructional strategies. Therefore, the null hypothesis of no significant difference in Pretest-Posttest mean scores in the acquisition of Mathematics process skills of students taught Geometry through jigsaw cooperative and lecture instructional strategies is rejected.

Hypothesis Two: There is no significant effect of jigsaw cooperative instructional strategy on senior secondary school students' retention in the acquisition of Mathematics process skills.

Table 3: Mean and Standard Deviation of Students' Retention of Mathematics process skills in Jigsaw Cooperative and Lecture Instructional Strategies.

Groups	N	Pretest Mean (X)	SD	Retention test Mean (X)	SD	Mean Gain
Jigsaw Cooperative Strategy	31	10.52	2.83	9.58	3.57	-0.94
Lecture Strategy	27	7.59	6.60	6.26	2.74	-1.33

The data in Table 4 show that students in the Jigsaw cooperative strategy got a mean score of 10.52 and a standard deviation of 2.83 in posttest, a mean score of 9.58 and a standard deviation 3.58 at retention test; making a mean gain of - 0.94. For the Lecture strategy group, the participants got a mean score of 7.59 at posttest and a standard deviation of 2.60, a mean score of 6.26 and a standard deviation of 2.74 at retention test; making a mean gain of -1.33. The results further indicated that Jigsaw cooperative strategy group which had a mean gain of -0.94 did better than the Lecture Strategy group had mean gain of -1.33. To conclude on whether or not the observed retention test mean differences are significant, ANCOVA statistics was utilized to test hypothesis two as presented in Table 5.

Table 4: Analysis of Covariance (ANCOVA) of Students' Retention of Mathematics process skills in Geometry at Retention test

Dependent Variable: Posttestconexp

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	194.341[a]	2	97.170	9.868	.001	.264
Intercept	353.221	1	353.221	35.871	.000	.395
Pretestconexp	35.144	1	35.144	3.569	.064	.061
Strategies	68.153	1	68.153	6.921	.011	.112
Error	541.590	55	9.847			

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Total	541.590	55	35.144	35.871	.000	.395
Corrected	4480.000	58	68.153	3.569	.064	.061
Total	735.931	57	9.847	6.921	.011	.112

a. R Squared = .264 (Adjusted R Squared = .237)

Table 4 shows the ANCOVA analysis of students' retention of Mathematics process skills in Jigsaw cooperative and Lecture instructional strategies at retention test. The results indicate that $F_{(1, 55)} = 6.921$, $p = .01 < 0.05$ which is significant at 0.05 alpha level. This means that there was a significant difference in the mean scores of students' retention of Mathematics process skills taught Geometry using Jigsaw cooperative and Lecture instructional strategies. Therefore, the null hypothesis of no significance difference in Posttest-Retention test mean scores of Mathematics process skills students taught Geometry with Jigsaw cooperative and lecture instructional strategies at retention test is rejected.

Discussion of Findings

The findings of this study from hypothesis one (HO_1) presented in Tables 1and 2 revealed that the mean scores of Mathematics process skills acquired by the Jigsaw cooperative instructional strategy students differ significantly from those exposed to Lecture method due to the higher mean scores obtained by the Jigsaw cooperative instructional strategy students. The results indicate that $F_{(1, 55)} = 10.533$, $p = .00 < 0.05$ which is significant at 0.05 alpha level. The result further showed that students taught Geometry with Jigsaw cooperative instructional strategy improved significantly in the acquisition and retention of Mathematics process skills compared to those exposed to Lecture method. The result also shows that treatment is responsible for 16.1% of the observed variance in the dependent variable. The finding of this study is in agreement with finding of Timaya (2016) who concluded that the Jigsaw cooperative instructional strategy significantly improved the performance and interest of students in

Geometry compared to the Lecture method.

The findings of this study from the result showed in Tables 3 and 4 revealed that students taught Geometry with Jigsaw cooperative instructional strategy improved significantly in the retention post test of Mathematics process skills compared with and those exposed to Lecture method. The findings of this study is that there was a significant difference in the mean scores of students' retention of Mathematics process skills taught Geometry using Jigsaw cooperative and Lecture instructional strategies.The results indicate that $F_{(1,\ 55)} = 6.921$, $p = .01 < 0.05$ which is significant at 0.05 alpha level. The result also shows that treatment is responsible for 11.2% of the observed variance in the dependent variable. This finding confirms the findings ofChianson, Kurumeh and Obienyem (2011) on cooperative learning strategy who concluded respectively in their studies that students' centred strategies significantly improved students' performance better than the lecture strategy due to the fact, it aids their retention ability.

Conclusion

The study found a significant impact of the Jigsaw Cooperative Instructional Strategy (JCIS) on the acquisition and retention of Mathematics Problem-Solving (MPS) skills among Senior Secondary School II students, compared to the conventional lecture method as a result, the instructional strategy employed by the researchers significantly enhanced students' performance in both acquiring and retaining MPS. This improvement is attributed to the increased engagement of students in activities, which is not typically seen in traditional lecture formats.

Recommendations

The following are recommended, based on the major finding of the study:

1. Mathematics teachers should be encouraged to adopt JCIS to teach Geometry to enhance students' active participation for better understanding content.

2. Students should be given privilege to develop skills through the use of JCIS to expose them to self- discoveries strategy that will enhance their productivity.
3. Professional development for Mathematics teachers on Jigsaw cooperative instructional strategy in form workshops, seminars, conferences and other in-service training on Geometry in the secondary schools should be done by the government.

Contribution to Knowledge

The importance of this research is immense. It broadens the range of instructional strategies available to Mathematics educators, providing new tools to improve teaching and learning effectiveness. By enhancing students' ability to acquire and retain knowledge, the study seeks to boost academic performance. It represents a significant contribution to the literature on secondary Mathematics education and aligns with worldwide initiatives aimed at improving student outcomes. Additionally, the research emphasizes the potential of the Jigsaw Cooperative Instructional Strategy (JCIS) to promote critical thinking and foster creativity among students.

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